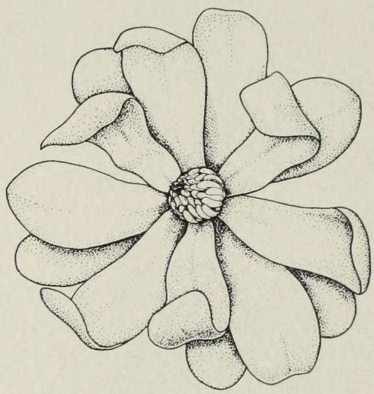

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Two New Species (*Didissandra porphyrantha* and *Didymocarpus nitidus*) and a New Combination (*Didymocarpus breviflorus*), Gesneriaceae, from Selangor, Malaysia

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Abstract

Two new species of Gesneriaceae, *Didissandra porphyrantha* (Section Speciosae) and *Didymocarpus nitidus* are described and illustrated. A new combination, *Didymocarpus breviflorus*, is made for a species previously included in *Didissandra*.

Introduction

During the course of field work in Selangor, one of us (RK) located populations of several interesting species of Gesneriaceae. Two of these, on further investigation, were found to be new species, *Didissandra porphyrantha* and *Didymocarpus nitidus*, and another, *Didissandra breviflorus* Ridl., with the collection of flowering material, proved to be a species of *Didymocarpus.*

The new *Didissandra* species is particularly striking with large violet-purple flowers with an almost black limb, and so earns the epithet *porphyrantha*. It is a handsome plant worthy of cultivation. The new *Didymocarpus* species is notable for its shiny, rather fleshy leaves and is therefore called *D. nitidus*. Its flowers are white and are rather small. This species seems to flower rather rarely and is usually encountered sterile.

Both *Didissandra porphyrantha* and *Didymocarpus nitidus* are found in montane forest on a steep slope east of the summit of Gunung Bunga Buah where they grow in a richly developed herb layer, which includes other species of Gesneriaceae such as *Didymocarpus* cf. *albinus, D. malayanus* and *D. platypus* (a form with purplish corolla lobes illustrated by Kiew, 1982). *Didymocarpus nitidus* is as yet known only from this locality but *Didissandra porphyrantha* has been found lower down the Gombak valley. As yet *Didymocarpus breviflorus* is only known from Selangor from several places in the Gombak valley as well as from Genting Peras.

Didissandra porphyrantha A. Weber & R. Kiew, *sp. nov.* Fig. 1, 2.

Planta lignosa, 20–50 cm alta. Caulis simplex vel ramosus, in parte inferiore decumbens et radicatus. Folia in apice caulis laxe aggregata, per internodia c. 2 cm longa et pilis rubro-brunneis obsita separata, opposita; petiolus 2–3 cm longus, e pilis rubro-brunneis villosus; lamina 10–20 x 3–6 cm, oblanceolata, partim subfalcata, apice acuminato, basi attenuata, margine grosse serrato-crenato (dentes 1.5 mm longi,

Fig. 1. *Didissandra porphyrantha*. a,b flower; c fruiting specimen. (Photo. A. Weber)

c. 1 cm distantes); pagina superior glabra (in foliis juvenilibus glandulis minutissimis 2-cellularibus obsita), pagina inferior in nervis laxe villosus. Pedunculi axillares, 5–8 cm longi, subglabri, 1–2 flori; bracteae 2, lanceolatae; pedicellus 1–1.5 cm. Sepala 5, anguste triangularia, in dimidio inferiore connata, subglabra. Corolla c. 5 cm longa, infundibuliformis, basin versus anguste cylindrica; tubus extra glaber, violaceus, intus atro-violaceus, lineis albis longitudinalibus 8 ornatus; limbus atro-violaceus, fere ater. Stamina 4, didynamia, per paribus cohaerentes. Discus cylindricus, brevis, 5-lobatus. Ovarium cylindricum, basin versus angustatum; stylus brevis; stigma unilabiatum, planum, triangulare vel reverse cordatum. Fructus capsularis, elongato-linearis, carnoso-cartilagineus, 6–8 cm longus, leviter curvatus, in latere superiore rima longitudinali dehiscens. Semina numerosa, parva, atrobrunnea, elliptica vel late fusiformia, striata.

Fig. 2. *Didissandra porphyrantha*. a,b. glands on juvenile leaf; c. seed; d. testa surface enlarged. SEM-micrographs bar: a,c. 100μm; b,d. 10μm.

Type: Peninsular Malaysia, Selangor, Gunung Bunga Buah, on ridge east of summit, 1300–1400m, *Weber & Anthonysamy 840711-1/3* (WU; iso E, K, KLU, L, WU, UPM).

Woody plant, 20–50 cm tall. Stem unbranched or branched, decumbent and rooting, the upper, erect leaf-bearing part villous with red-brown hairs. Leaves opposite, loosely tufted, internodes c. 2 cm. Petiole 2–3 cm, red-brown hairy. Lamina 10–20 by 3–6 cm, oblanceolate, partly subfalcate, tip acuminate, base narrowed, margin coarsely serrate-crenate (teeth c. 1.5 mm long, c. 1 cm distant), angles between teeth raised, giving the margin an undulate appearance, upper surface glabrous (young leaves with minute, 2-celled glands, which later collapse, scarcely visible with a lens), lower surface with veins sparsely hairy on the flanks.

Peduncles axillary, 5–8 mm long, glabrous or sparsely hairy, 1 to 2-flowered, bracts 2, lanceolate, sparsely hairy, pedicel 1–1.5 cm. Sepals 5, connate in the lower part, lobes narrowly triangular, tip blunt, (sub)glabrous. Corolla c. 5 cm long, broadly cylindric, somewhat compressed, base narrow cylindric, limb slightly bilabiate, lobes 5, rounded, tube glabrous outside, violet, limb dark violet, nearly black, throat with 8 white lines running from the mouth to the interior. Stamens 4, white, didynamous, cohering in pairs by the apex of the anthers at right angles to the filaments. Disc shortly cylindrical, shallowly 5-lobed. Ovary cylindrical, tapering towards the base, style short, stigma formed from the lower carpel alone, flat, broadly triangular to (reversely) heart-shaped. Capsule slender, 6–8 cm long, hard and thickly fleshy, slightly curved, tapering towards the base, splitting on the upper side by a longitudinal slit. Seeds small, numerous, blackish-brown, elliptic to broadly spindle-shaped, testa with longitudinal bars (thickenings).

Other collections: Selangor: Comp. 25, Ulu Gombak F. R., 1973, *Kochummen FRI 16722* (KEP); type locality *Anthonysamy* 1980 *SA 337* (UPM), *R. Kiew* 6 June 1981 *RK 1040* (UPM); Waterfall on Sungai Batu at 200m *Kiew B. H.* 2 Feb 1986 *RK 2096* (UPM).

Habitat: Locally common, forming clumps in undisturbed forest, on slopes in shade and at lower altitudes (200m) in shaded forest in the same valley system.

Notes: Didissandra porphyrantha is a handsome plant with large, beautiful, dark purple flowers (Fig. 1). The floral tube is violet outside (paler towards the base), the limb is deep violet almost verging on black. Eight white lines in the throat run from the mouth to the base, contrasting sharply with alternating dark lines.

It belongs to Section Speciosae, which presently numbers 15 species in Peninsular Malaysia. It can be told apart from other species in this section by its coarsely serrate-crenate leaves, which are glabrous on the upper surface (though they are sparsely studded with two-celled glands when young, (Fig. 2a, b), the more or less glabrous sepals, which are connate in the lower part, and the glabrous corolla.

The large (5 cm long) deep purple flowers are not unique in the genus or section. Two species, *D. atrocyanea* and *D. atropurpurea*, share these features and their specific epithets reflect the striking colour of their flowers. The flower of *D. atrocyanea* is described by Ridley (1923) as "black purple, mouth nearly black" and must therefore be very similar to *D. porphyrantha. D. atrocyanea* is, however, easily distinguished by vegetative characters: its leaves are conspicuously hairy and appear punctate on the lower surface; the leaf margin is closely serrate with a hair on each tooth and the plant appears to be smaller with a more rosette-like habit. *D. atropurpurea* is distinguished by having more or less entire leaves (the margin is very obscurely crenate) and very short pedicels so that the bracts are placed close to the calyx.

Several other species are described by Ridley as having violet flowers (*D. hirta, D. longisepala, D. morgani, D. petiolata* and *D. violacea*) but their flowers are smaller (2.5 to 3.5 cm long) except for *D. longisepala* which has flowers 5 cm long. *D. longisepala,* however, differs from *D. porphyrantha* by having, according to Ridley, long petioles (7 cm long) and exceptionally long peduncles (10 cm long).

Nothing is known about the pollination of these peculiarly coloured flowers. One wonders which animal (probably largish insects) are attracted to the dark purple colour.

Didymocarpus nitidus R. Kiew & A. Weber, *sp. nov.* Fig. 3, 4a, b & c.

Planta lignosa, 30–40 cm alta. Caulis simplex, 40–70 cm longus, 0.5 cm in diametro; pars inferior decumbens et radicatus. Folia opposita, in parte superiore caulis aggregata, internodiis 0.5–2 cm longis separata; petiolus 1.5–2.5 cm, pilis ± adpressis obsitus; lamina lanceolata, 10–15 x 2–3.5 cm, in apice et in basi attenuata, margine crenulata; pagina superior atrovirens, glabra, nitida; pagina inferior pallide viridis vel albidus, nervis perspicuis; nervi e pilis ± adpressis hirti; nervi laterales 15–10, oppositi vel subopposití, arcuati. Pedunculi axillares, 6–10 cm, pubescentes, bracteis minutis linearibus 2 in parte superiore, 1-flori. Sepala 5, c. 2 mm, anguste triangularia, obtusa, e pilis brevibus hispida. Corolla 13–15 mm, alba; tubus et limbus extra e pilis minutis pubescentes; limbus bilabiatus, 5-partitus, lobis rotundatis. Stamina 2, antheris globularibus cohaerentes. Discus annularis. Ovarium cylindricum, c. 6 mm, pilis brevibus et glandulis minutis obsitum; stylus 3 mm; stigma inconspicue capitatum. Fructus capsularis, cylindricus, 4–4.5 cm, e pilis erectis nigris laxe strigosus, in latere superiore rima longitudinali dehiscens. *Type:* Peninsular Malaysia, Selangor. Gunung Bunga Buah, east of summit, 1300–1400 m, *Weber & Anthonysamy 840711-1/1* (WU; iso E, K, KLU, L, WU, UPM).

Woody, unbranched plant 30–40 cm tall. Stem 40–70 cm long, 0.5 cm thick, strongly woody, decumbent and rooting. Leaves paired, forming a loose tuft at the top of the stem, internodes 0.5–2 cm. Petiole 1.5–2.5 cm with short, ± appressed, brownish hairs. Lamina lanceolate, 10–15 by 2–3.5 cm, gradually narrowed at both ends, margin obscurely crenulate, upper surface *in vivo* deep-green and shiny, glabrous; lower surface pale green to whitish (copper-brown when dry), with prominent, hairy veins, veins 15–20 pairs, opposite or subopposite, arched.

Peduncles axillary, 6–10 cm, shortly hairy, with 2 minute, linear bracts on the upper part, single flowered. Sepals 5, c. 2 mm, narrow-triangular, blunt, shortly hispid.

Fig. 3. *Didymocarpus nitidus* in its natural habitat. (Photo. A. Weber).

Corolla 13–15 mm long, white, outside of tube and limb pubescent with short hairs, limb bilabiate, 5-partite, lobes rounded, lower lobe projecting straight forward. Stamens 2, anthers globose, cohering at the tips. Disc annular. Ovary cylindrical, c. 6 mm long with short hairs and minute glands, stigma inconspicuously capitate. Capsule 2–5 cm long, straight, sparsely strigose with black, erect hairs, opening by a longitudinal slit on the upper surface.

Other collections: Selangor, type locality: *R. Kiew* 22 Sept 1978 *RK 666* (UPM), *Anthonysamy* 1980 *SA 338* (UPM), *R. Kiew* 16 May 1982 *RK 1166* (UPM), *R. Kiew* 18 March 1984 *RK 1285* (UPM).

Habitat: Common in one locality in undisturbed montane forest, on steep slopes near the top of a ridge, in shade.

Notes: Didymocarpus nitidus can be distinguished from other *Didymocarpus* species by the following combination of characters (for measurements see description): unbranched, woody stem with rather short internodes; leaves lanceolate, deep green, glabrous and shiny on the upper surface, pale green to whitish on the under side

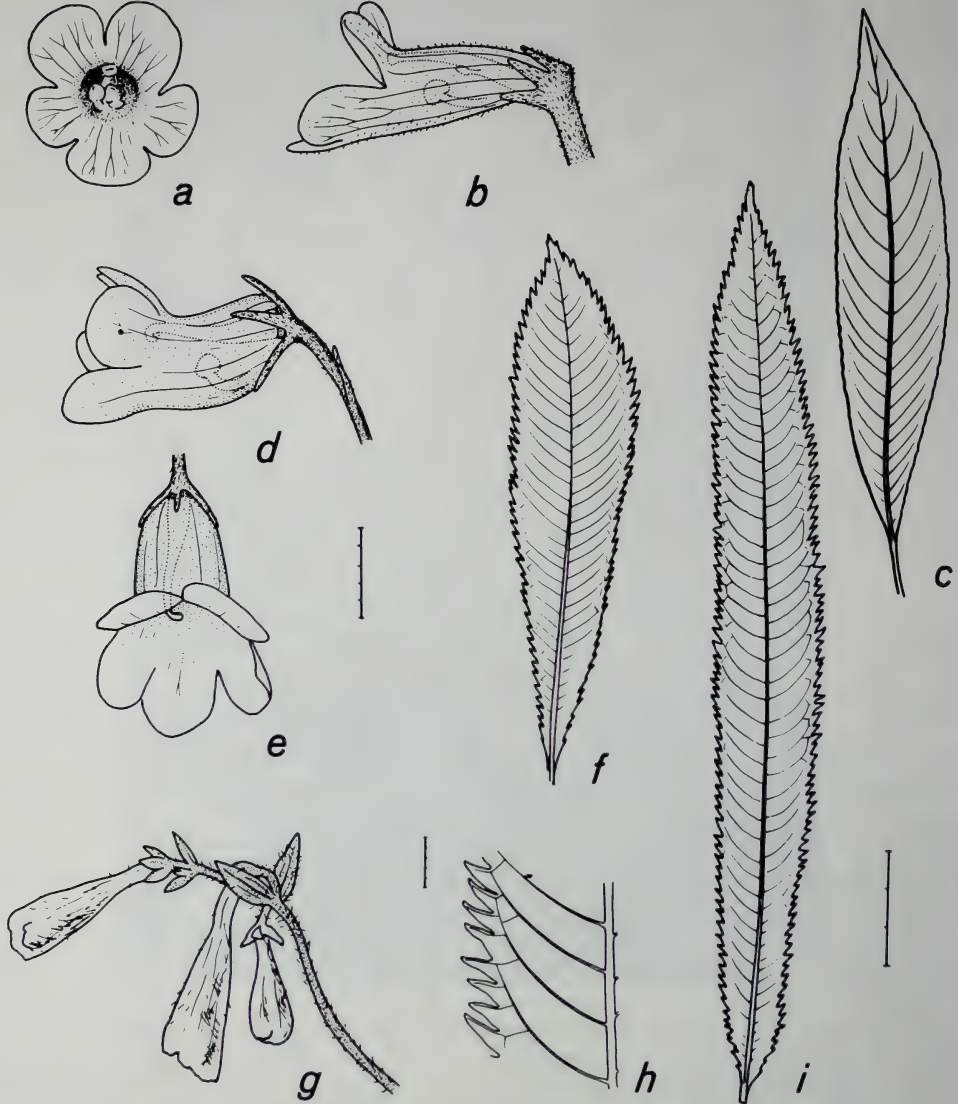

Fig. 4. a–c. *Didymocarpus nitidus*, flower and leaf. d–f. *Didymocarpus breviflorus*, flower and leaf. g–i. *Didymocarpus serratifolius*, inflorescence, portion of leaf, and leaf. Bar 5 mm flowers; and 3 cm leaves.

(Fig. 3); margin obscurely crenulate (Fig. 4c); peduncles half (or more than half) as long as the leaves, single flowered; flowers small with a rather broad, straight tube, pure white (Fig. 4a, b).

The shiny leaf surface may in part be attributed to a lack of non-glandular uniseriate hairs which are common in other species of *Didymocarpus* (Norana, 1982). (These non-glandular hairs are also absent from the upper surface of *Didissandra porphyrantha*). Both these species possess stalked glandular hairs, a common feature of both *Didissandra* and *Didymocarpus.*

Didymocarpus nitidus is unique among *Didymocarpus* species (Norana, 1982) in that these glandular hairs are completely sunken below the leaf surface which is flat and these two features contribute to the leaf's gloss. Some species of *Didymocarpus* do not have a flat leaf surface but instead are mammillate, e.g. *D. platypus*, or have a papillose epidermis, e.g. *D. malayanus.*

Didymocarpus breviflorus (Ridl.) A. Weber & R. Kiew, *comb. nov.* Fig. 5.

Didissandra breviflora Ridl. Kew Bull. 10 (1926) 474.

Holotype: Peninsular Malaysia, Selangor, Ulu Gombak, c. 1500 ft., 23 Sept 1921, *Hume 8437* (SING).

Stem erect, woody, usually unbranched. 10–25 cm tall and 3–6 mm thick, in the upper part densely covered by long, brown hairs (grey-brown when dry). Leaves obscurely decussate, crowded at the top of the stem and forming a tuft. Petiole 1–2.5 cm long, densely covered by long (grey-) brown hairs. Lamina oblanceolate (to lanceolate), partly subfalcate, 9–20 cm long by 2.5–5.5 cm wide, light green *in vivo*, margins strongly serrate, teeth c. 3 mm long and 1.5–2 mm wide at base, tip obtuse, with 14–19 teeth per 5 cm, *in vivo* the base of the tooth slightly raised (pouched) with the tooth directed downwards, lateral veins opposite or subopposite, forming a conspicuous succession 3–4 mm apart, parallel, slightly curved, each vein forking just below a marginal tooth, the strands of adjacent veins anastomosing and sending a short strand into the sinus between two teeth, upper surface glabrous, midrib sometimes with sparse, long hairs, lower surface whitish (grey-brown when dry), with loose long hairs on midrib and lateral veins.

Peduncle axillary, one to several (in a row) arising from a leaf axil, 8–10 cm long, purple, sparsely covered by long hairs, single flowered. Bract pair subopposite, green, c. 5–10 mm below the flower, linear-obtuse. Sepals 5, linear, obtuse, 3 mm long,

Fig. 5. *Didymocarpus breviflorus*. a. Fruiting plant in natural habitat. b. Flower of cultivated specimen. (Photo. A. Weber).

Table 1
Diagnostic characters for *Didymocarpus breviflorus* and *D. serratifolius.*

	D. breviflorus	*D. serratifolius*
Hairs on stem	pale fawn, long, silky	ferrugineous, hispid
Petiole length (cm)	1 - 2.5 (–4 in lower leaves)	± decurrent (–1.5 in lower leaves)
Leaf	oblanceolate (– lanceolate)	narrowly lanceolate
Leaf width (cm)	2.5 - 5.5	1.5 - 3
Leaf width: length	1 : 2–4	1 : 5–8
Indumentum on lower surface of midrib	pale fawn, short, dense	ferrugineus, long
No. vein pairs	20 - 33	40 - 50
Marginal teeth		
length (mm)	3 - 5	2 - 3
apex	rounded	jagged
No. flowers per peduncle	1	several (–4)
Sepals	linear, tip blunt	ovate, tip acute
Corolla form	shortly and broadly tubular	trumpet-shaped, base narrowed
Corolla length (mm)	10 - 14	13 - 22
Fruit indumentum	none	shortly pubescent

purple, with sparse ± appressed hairs. Corolla 10–14 mm long, tube broad-tubular, c. 4 mm in diameter, curved, lobes 5, rounded, nearly equal, pale violet to nearly white, very shortly hairy outside (scarsely visible in dry flower). Stamens 2, c. 3 mm long, anther c. 1.5 mm long, thecae widely divaricate. Disc shortly cylindric, surrounding the ovary base. Ovary oblong with minute, stalked glands. Style strongly curved down in the upper part, stigma capitate. Capsule linear, glabrous, 3–5.5 cm long, opening by a longitudinal slit on the upper side, making an angle of 60–120° with the peduncle. Seeds numerous, minute, elliptic, testa reticulate, with fine pustules.

Specimens examined: Selangor — Genting Simpah 700 m, 29.10.1937 *Md. Nur SFN 34298* (E); Old Gombak Road, 17th milestone upwards to Genting Simpah 330–500 m, *Allen 3451* (SING); Waterfall on Old Gombak Road, 12.7.1984 *Weber & Anthonysamy 841207-1/1* (WU); 25.11.1984 *Kiew RK1551* (UPM); Genting Peras, 10.2.1985 *Kiew RK 1614* (UPM).

Habitat: Hill forest, on vertical rock faces or steep banks. (Ridley (1926) incorrectly quotes the altitude of the type specimen as 500 ft).

Notes: Ridley's description of *Didissandra breviflora* is not only brief but also does not include a description of the stamens which he was "unable to see" in the "one crushed flower" available to him. Here a comprehensive description is given based on a wider range of specimens, including fresh material.

As the stamen number is two (instead of four, which characterises *Didissandra*), the species is transferred to *Didymocarpus*. It fits neatly into Section Pectinati as its leaves are bunched in a tuft at the top of a woody stem and have a serrate margin (Fig. 5a) and it has short, tubular flowers (Fig. 5b).

Didymocarpus breviflorus most closely resembles *D. serratifolius* (Fig. 4g–i) in its venation and conspicuously serrate margin. It is distinguished from *D. serratifolius* by the characters listed in Table 1.

It occupies a distinct habitat. It grows on vertical rock faces or steep earth banks which are bare of other vegetation or leaf litter. In this habitat, it may be common but it is not found in other habitats in the vicinity. This suggests that its seedlings are intolerant to being covered by leaf litter.

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References

Kiew, R. (1982). *Didymocarpus platypus* (purple form). *Malayan Naturalist* 35 (3):24.

Norana Ghazali (1982). *Comparative anatomy of common species of Didissandra, Didymocarpus and Chirita (Gesneriaceae)*. Unpublished project thesis, Department of Biology, Universiti Pertanian Malaysia.

Ridley, H.N. (1923). *Flora of the Malay Peninsula*. Vol. II. Reeve & Co., London.

Ridley, H.N. (1926). Additions to the Flora of Malaya. *Didissandra breviflora. Kew Bull.* 10:474.

Plantlet Production of *Swietenia macrophylla* King through Tissue Culture

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Abstract

Different vegetative parts of *Swietenia macrophylla* King were used as explants in *in-vitro* studies. They were cultured in MS medium supplemented with various plant growth regulators. Adventitious shoots could be obtained from the friable callus when the seedling nodal segments were cultured on BA (2, 5 ppm) media. The regenerated shoots could be rooted to form whole plantlets which could be transferred to soil.

Introduction

There has been considerable progress made recently in regenerating plantlets of tropical hardwood trees through tissue culture (Lee & Rao, 1981; 1986; 1987, Rao & Lee, 1986, Rao, 1988). The technique has great potential for exploitation in the mass production of propagules of forest tree species to implement afforestation and reforestation programmes. In this paper, the *in-vitro* culture response of various explants of *Swietenia macrophylla* King (Broadleaf Mahogany) is reported. The usefulness of *S. macrophylla* is very clearly explained in the tree flora of the S.E. Asian region (Corner, 1952).

Materials and Methods

Seedlings of *S. macrophylla* were established in sand. Both nodal and internodal segments of about 0.5 cm length were used as explants. Nodal segments from young basal shoots of some 10-year old trees were also used in the experiments. These explants were lightly washed in running water and later surface sterilised for about 10 minutes in 10% (w/v) freshly prepared sodium hypochlorite solution. Tween 20 was added as wetting agent. To reduce the exudation of phenolic compounds into the media, the nodal segments from the trees were soaked in sterile water for about 2 hours, after surface sterilisation. Seedling nodal segments did not require this treatment. Leaf tissue from shoots regenerated under *in-vitro* conditions were also used to test their growth response.

Murashige & Skoog (1962) medium was used with 2% sucrose and 0.7% Difco Bacto Agar. The macronutrients were reduced to half strength to lower the salt concentration. However, the concentration of ammonium nitrate was increased to 2 g/l to increase the level of reduced nitrogen. The media were supplemented with different concentrations and combinations of benzyladenine (BA), Indole-acetic acid (IAA), Indole-butyric acid (IBA), and Kinetin (K). All cultures were maintained at

22°C to 25°C with a photoperiod length of 16 hours of Philips white flourescent light at 35–45 μmole. $em^{-2}s^{-1}$, followed by 8 hours darkness. Each treatment was replicated 10 times and each experiment was repeated twice. For histological studies, selected tissues of varying ages developed *in-vitro* were fixed in formalin acetic alcohol (1:1:18). Standard practices were followed for dehydration, microtoming and staining with hematoxylin and erythrosin (Sass, 1968).

Results

Response of explants on IAA + K media on a 5^2 factorial combination: Both seedling explants as well as those excised from the mature (10–year old) trees were inoculated onto IAA and K media (0, 1, 2, 5 and 10 ppm each), in a 5^2 factorial combination. The nodal segments of young shoots excised from 10–year old trees remained green without much response. Although the axillary buds in some replicates (IAA [0 to 2 ppm] and high K [5 to 10 ppm]) enlarged to some extent, they remained dormant and no shoots developed. About 60% of the replicates turned brown about 12 days after inoculation and there was no further growth.

Growth was also slow in the nodal and internodal segments from the seedling axis. All segments remained fresh. The explants on media with high IAA (5, 10 ppm) and K (0 to 10 ppm) started growing 25 to 30 days after inoculation. In about 70% of the cultures, the middle region of the segments enlarged and small 'swellings' developed when they were subcultured onto fresh medium 40 days after the first inoculation. In cultures of about 50 to 60 days old, many small lobes of compact callus developed which enlarged further in 60 to 70 days (Fig. 1). In all the cultures, the axillary buds remained dormant, and did not emerge as shoots.

Response of nodal segments on BA media: In view of the limited response seen above, an attempt was made to induce multiple shoots by culturing nodal segments both from seedlings and old trees, in BA (0 to 10 ppm) media. The nodal segments from the trees failed to respond. About 50% of the replicates turned brown within 10 to 12 days after inoculation and subsequently died.

With the nodal segments from seedlings, growth improved in all the media used. In BA media (0.1 and 1 ppm), the axillary buds sprouted into shoots about 20 days after inoculation. Shoot growth was slow and within 14 days from sprouting, the tiny leaves that developed defoliated. No subsequent development was observed, irrespective of the concentration used.

Figure 1 to 8. *(opposite page)*

Fig. 1. Compact callus developing from a nodal segment cultured on IAA (5.0 ppm) + K (2.5 ppm) medium (60 days). Many lobes were obtained but growth is limited.

Fig. 2. Small shoots with whitish leaves developing from the callus cultured on BA (2 ppm) medium (70 days).

Fig. 3, 4, 5. Several shoots obtained from the callus subcultured continuously on BA (2 ppm) medium. These were the 4th subculture and they were about 120 days after inoculation.

Fig. 6. A rooted plantlet of *S. macrophylla,* with a single root.

Fig. 7. A periderm was formed at the cut surface of the nodal segment that was immersed in BA (2 ppm) medium (10–12 days). Note the cambial initiation.

Fig. 8. About 6 to 8 layers of cambial tissue were formed (15 to 20 days). The cells on the outer region were rounded and large.

Figure 1 to 8

The best response was obtained in BA (2 and 5 ppm) media. The axillary buds sprouted 10 days after inoculation, with each bud giving rise to a small reddish brown shoot. The growth was vigorous and shoots measured 1.5 cm in length in about 25 to 30 days. Thereafter, the growth rate slowed down, and the lower leaves defoliated. At this stage, the shoot segments were subcultured onto fresh media of similar composition, otherwise, the new axillary shoots would remain dormant and leafless. Even after subculturing, only slight elongation of the shoots was observed and no multiple shoots developed.

Along with the axillary shoots, callus developed at the basal region of the segments in about 2 weeks (Fig. 2). The growth progressed further and about one month after inoculation, the surface layers ruptured lightly at certain loci, to release small specks of whitish and friable callus. These were subcultured once in 3 weeks to encourage further tissue growth.

About 9 weeks after the first inoculation, small whitish buds developed on the surface of the brown callus. Some of these developed into shoots with whitish or pale coloured leaves (Figs. 2, 3), and in 10 days after emergence, the leaves turned greenish. These shoots grew to a height of 1 to 3 cm within 25 days after emergence. A cluster of 6–7 shoots was formed around a single clump of friable callus (Figs. 4, 5), and these shoots were excised for rooting. After excision of the mature shoots, new shoots were induced when the brownish and friable callus clump was subcultured onto a fresh medium.

Anatomical studies showed that about 10 to 12 days after inoculation, a distinct periderm was formed at the cut surface of the nodal segment and a regular cambial zone was initiated below the damaged peripheral layers (Fig. 7). There was no visible change observed in the original cells in terms of losing their contents before the regeneration of the new cambium. The fully formed cambial zone was 5 to 6 layers deep and prominent (Fig. 8). The cambial formation was distinct but the distribution was discontinuous (Fig. 9). The new cells formed towards the exterior from the cambial activity were big, loosely arranged and of various sizes and shapes. Most of the peripheral cells were either rounded or elongated. In 2 to 3 weeks old callus,

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Figure 9 to 16. *(opposite page)*

Fig. 9. There were variations in cambial distribution and formation of loosely arranged tissue. The peripheral cells were of various shapes and sizes (25 days).

Fig. 10. A mass of compact callus tissue which contained meristematic layers divided in many planes, contributing to the growth of the callus mass. The peripheral cells were loosely arranged.

Fig. 11. Many growth nodules were present in some callus clumps. These consisted of meristematic cells which divided actively, contributing to the growth of the callus.

Fig. 12. Mature callus (60 days) with loosely arranged tissue, with a shoot primordium.

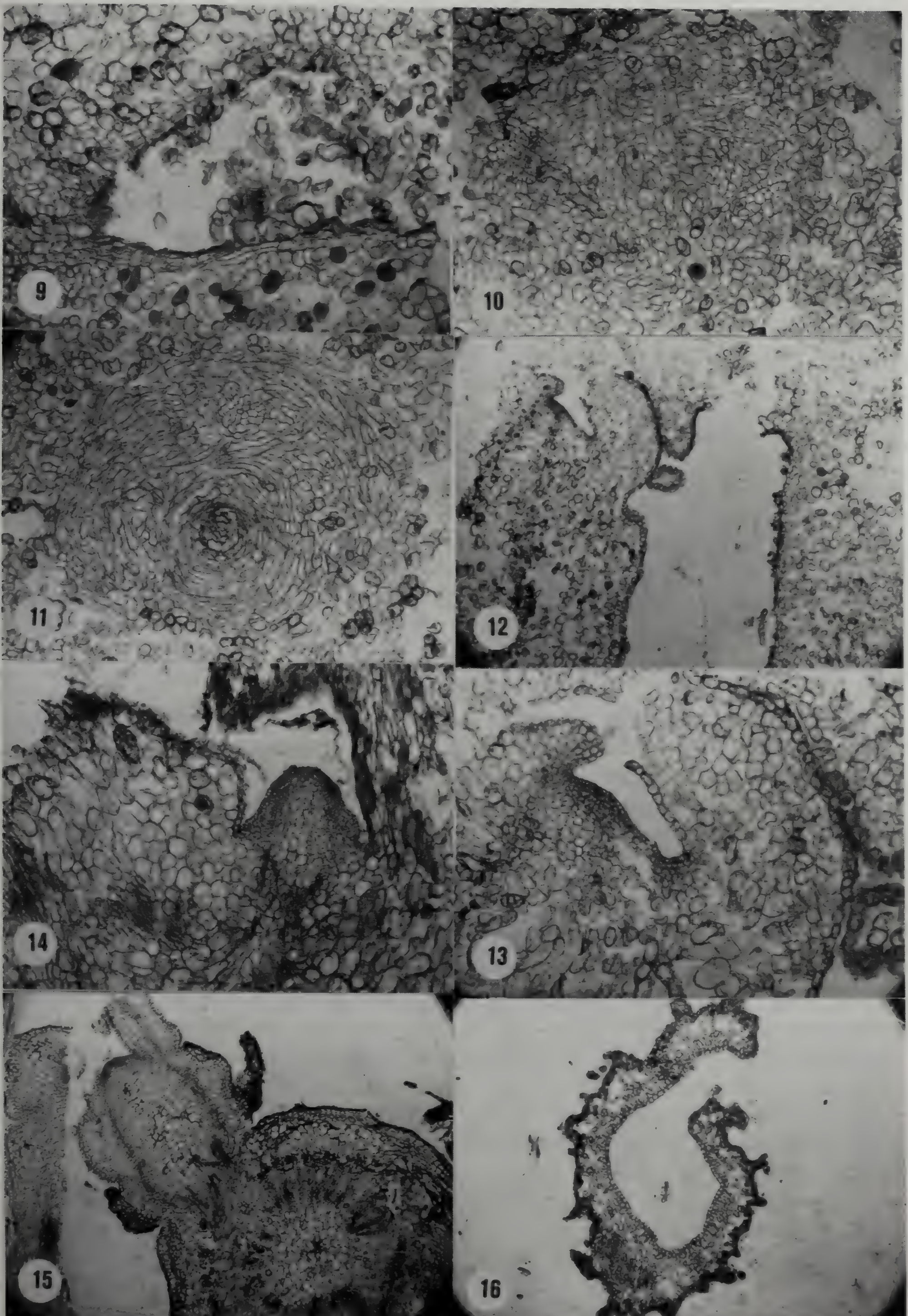
Fig. 13. The shoot primordium from Fig. 12, enlarged to show the shoot apex. The tunica-corpus zones were distinct.

Fig. 14. An axillary bud of a regenerated shoot, induced to grow in a BA (2 ppm) medium.

Fig. 15. New adventitious shoot growing directly from the secondary stem axis, in BA (2 ppm) medium (95–100 days).

Fig. 16. Leaf cultured on BA (2 ppm) medium (85 days). Several outgrowths from the lower epidermal layers were observed. Some of the outgrowths consisted of 8 to 10 cells (glandular) and could be detached from the epidermal layers.

Figure 9 to 16



the inner tissue was also compactly arranged although the peripheral free cells were loosely arranged (Figs. 9, 10). Within the new tissue, there were many meristematic regions and through their activity, additional tissue was formed, thereby contributing to the growth of the callus (Figs. 10, 11).

In callus 5 to 6 weeks old, distinct 'growth nodules' were present. Cells within the 'growth nodules' were compact and radially arranged in concentric rings (Fig. 11). These cells as well as those surrounding them were highly meristematic and through their active division, the volume of the callus increased. The cells towards the peripheral region of the 'growth nodules' were more rounded and they were loosely arranged, some with tannin contents (Fig. 11). The old tracheal cells remained in the centre with the new cell layers around them (Fig. 11). In the newly formed tissue 2 islands of secondary phloem were regenerated.

Shoot primordia developed from the friable callus in about 60 days after inoculation (Fig. 12). In the axis the cells of different sizes and shapes were loosely arranged with many air spaces bounded by a distinct epidermis. The peripheral layers remained fairly intact despite loose tissue inside. At certain loci, a single or a group of meristematic cells organised into shoot primordia. Further growth led to the development of a shoot apex with a distinct tunica corpus and the leaf primordia (Figs. 12, 13). With subsequent subculturing, additional shoots developed with new axillary buds (Fig. 14). They developed into secondary shoot after the third subculture (about 80 to 95 days from first inoculation). These also developed into normal shoots. Another interesting feature was the direct development of free buds on the internodes. They started as small swollen structures attached to the exis at an angle. The transverse section of the axis showed their relationship very clearly and most of them developed from the inner cortical tissue. Leaf primordia were distinct and the ones formed earlier were scale-like with basal meristematic tissue. Obviously they can be used as explants to regenerate further tissue growth (Fig. 15).

Response of leaf tissue on BA media: Young leaves excised from regenerated shoots were inoculated onto media supplemented with BA (0 to 10 ppm). Except for media supplemented with BA (2, 5 ppm) no response was observed in the others. The leaf tissue turned brown on BA (10 ppm) medium in about 4 days after inoculation. Hypertrophic growth was seen in explants at BA medium (2 ppm), resulting in the leaf blade curling up into many folds. On the surface many small outgrowths were also observed.

Anatomical studies showed two growth patterns, (a) the leaf blade was folded upward because of excessive growth in the region of the lower epidermis and, (b) the epidermal and subepidermal layers were wavy, forming many small outgrowths (Fig. 16). At certain points mesophyll cells also divided, contributing to the formation of small outgrowths. Each one of these had a group of actively dividing cells.

Plantlet formation: The excised shoots were planted onto IBA (2.5 and 10 ppm) media to induce rooting and the initial response was slow. At the lower concentration (2 ppm), no root developed, whereas at higher concentrations (5 and 10 ppm), only some of the shoots rooted in about 40 days after inoculation. In each case, only 1 root was produced, growing horizontally to the shoot axis, resembling the primary root of the seedlings (Fig. 6).

Transfer of plantlets into Jiffy-7 pellets: The plantlets with single shoots were transferred to Jiffy-7 pellets which were stored within an enclosed translucent structure. They were each dipped in benlate solution prior to transfer, to avoid fungal infection. The survival rate was about 20%. The leaves were yellowish despite being fed with phostrogen, a soluble fertiliser. The saplings that developed were relatively weak. However, these could be revived with appropriate treatments and grown into healthy plantlets.

Discussion

The possibility of inducing adventitious shoots from callus and nodal segments is described. Thus there is a good potential for adopting *in-vitro* methods to produce propagules in large numbers. However, the average number of shoots that was produced per replicate in the present study was only about 6. Therefore further studies need to be conducted to establish the pattern for production of large number of propagules required for different programmes. Besides using nodal or internodal segments, leaf tissues should be used extensively to induce shoot growth. Large numbers of shoots were induced from leaf tissue of *Fagraea fragrans* Roxb. (Lee & Rao, 1986). In this study, leaf tissue of *S. macrophylla* also responded well in BA media, producing several outgrowths. If each of the outgrowths could be induced to differentiate into shoots, many shoots could be obtained from a single leaf section. Further work is in progress.

For *in-vitro* techniques to be effectively adopted, the plantlets produced must be healthy so as to ensure a high survival rate of quality plants when transferred to soil. This area needs to be refined further since a survival rate of only about 20% of the plantlets was achieved in the present studies. One of the causes could be due to the formation of only a single root which resembled a tap root. More roots might ensure a higher survival rate.

The inability of nodal segments from mature trees to respond is another area of concern. The problem of juvenility factors should be further explored. Various means to induce juvenile shoots to grow from mature plants, either through pruning or grafting, should be attempted in case of elite trees. The newly developed parts should be used as explants.

The present study has re-emphasised that BA is consistently effective in inducing organogenesis in callus or multiple shoot growth in nodal explants of woody plants (Zaerr & Mapes, 1982). Media supplemented with auxin and kinetin combinations were only able to induce callus growth but the presence of BA promoted shoot growth.

Conclusion

With further understanding of the growth responses of various explants and the factors affecting them, there is a good potential for adopting the tissue culture technique for producing propagules of *S. macrophylla* in large numbers. Such studies can be extended to include other useful economically important trees.

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References

Corner, E.H. (1952). Wayside Trees of Malaya. Government Printing Office, Singapore.

Lee, S.K. and Rao, A.N. (1981). *In-vitro* plantlet development in tropical trees — *Callophyllum inophyllum* and *Eugenia grandis*, pp. 185-190. In COSTED Symp. on Tissue Culture of Economically Important Plants. Ed. A.N. Rao, Singapore.

Lee, S.K. and Rao, A.N. (1986) *In-vitro* regeneration of plantlets in *Fagraea fragrans* Roxb. — a tropical tree. *Plant Cell, Tissue and Organ Culture* 7: 43-51.

Rao, A.N. and Lee, S.K. (1986). An overview of the *in-vitro* propagation of woody plants and plantation crop; 123–138, in Plant Tissue Culture and its Agricultural Applications. Ed. Withers, L.A. and Alderson, P.G., Butterworth, London.

Lee, S.K. and Rao, A.N. (1987). Propagation of some *Eugenia* species through Tissue Culture. (IDRC and FRIM publication, in press).

Rao, A.N. (1988). *In-vitro* culture studies on economically important tropical trees. (Biotrop publication, in press).

Sass, J.E., (1986). Botanical Microtechnique. The Iowa State University Press, Ames, Iowa.

Zaerr, J.B. and Mapes, M.O. (1982). Action of growth regulators, pp. 231–255. In Tissue Culture in Forestry. Ed. J.M. Bonga and D.J. Durzan. Martinus Nijhoff/Dr W. Junk Publishers, The Hague.

Compound Fertilizer Requirements for the Establishment and Early Growth of Popular Ornamental Shrubs between Road-side Trees

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Abstract

The fertilizer needs of some popular shade-loving shrubs were evaluated by a 1 year field trial. Plant growth was the same with or without inorganic fertilizer supplements irrespective of shade conditions and trial plants employed. Nutrients available from the planting mix comprising topsoil: treated sludge (3:1 v/v) appeared to be sufficient for the early growth of shade shrubs.

Introduction

Evaluation of fertilizer requirements of ornamental and landscape plants have been conducted extensively in the United States (Harris et al., 1977; Neely et al., 1970; Smith & Treaster, 1981, and van de Werken, 1981). Traditionally, fertilizer recommendations have been based on trunk caliper and in some cases on the soil surface area (Smith & Treaster, 1981). In the Parks and Recreation Department, Singapore, manuring practices are frequently, if not always, inferred and adopted from findings established for economic plants in the region. In the case of ornamental shrubs, they are often manured similarly irrespective of the edaphic factors e.g. light intensity of the habitat.

With the advent of the Garden City Campaign in Singapore, many road-side trees have been planted. The tree crowns have expanded over the years leaving much of the areas between under shade. Various suitable shade-loving shrubs have been established between trees to augment the adornment. However, empirical data pertaining to their fertilizer needs are lacking. Plants adapted to shade have metabolic rates and growth morphology which differ from those grown in full sun (Fails et al., 1982a, b & c; McClendon & McMillen, 1979 & 1982) and hence their fertilizer requisites are likely to be different. An interaction between shade intensity and fertilizer requirement has been observed for the growth of *Taxus x media* 'Hicksii' (Khatamian & Lumis, 1982). In order to eliminate guesswork from fertilizing shade shrubs, a field trial was initiated to provide the necessary information.

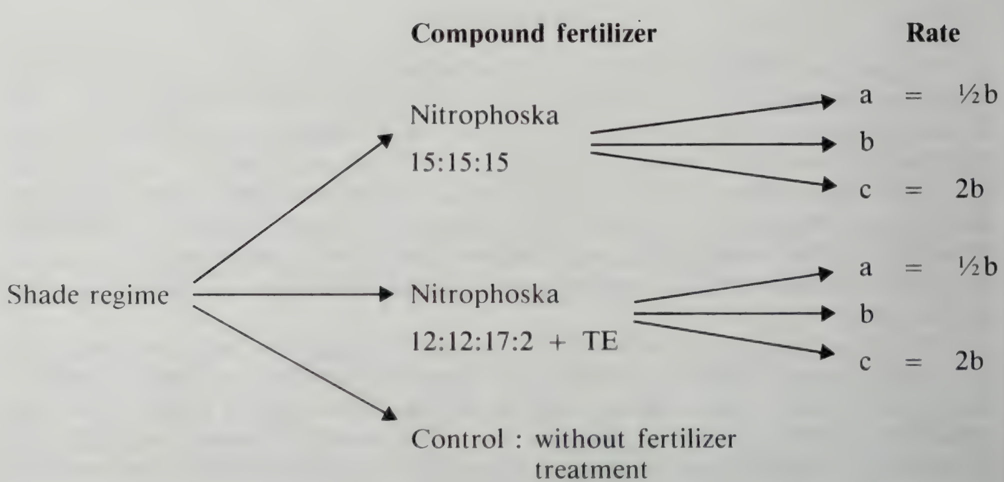
Materials and Methods

The experiment sites were on the East Coast reclaimed land under natural shade of *Acacia auriculiformis* A. Cunn. ex Benth. and *Samanea saman* (Jacq.) Merr. Three shade regimes were classified using the Li-Cor LI-185B photometer. The three shade regimes and the test shrubs selected for the different light conditions appear in Table 1. The test plants have been commonly planted under these specific shade regimes.

Table 1
Shade regimes and attendant test plants

Shade regimes	Experimental shrubs
1. Light shade Light intensity (LI) = 15,000 - 20,000 lux	a. *Ptychosperma macarthurii* (Wendl.) Nichols b. *Ixora javanica* (Bl.) DC.
2. Medium shade 10,000 < LI < 15,000 lux	a. *Philodendron selloum* C. Koch. b. *Polyscias filicifolia* L.H. Bailey
3. Dense shade 5,000 < LI < 10,000 lux	a. *Aglaonema pseudobracteatum* Hort. b. *Dracaena surculosa punctulata* Hort.

Two compound fertilizers, Nitrophoska 15:15:15 and 12:12:17:2 + TE, were tested against shrubs assigned to each shade regime at 3 rates viz: rate b = current practice of 100g per shrub at half yearly intervals, broadcasted; rate a = half the recommended dosage, and rate c = twice the recommended dosage. This is summarized for each shade regime as follows:-



The various treatments were as follows:

C	=	Control — without fertilizer treatment.
1a	=	Nitrophoska 15:15:15 applied at rate a (50g per shrub at half yearly intervals).
1b	=	Ibid but at rate b (100g per shrub at half yearly intervals).
1c	=	Ibid but at rate c (200g per shrub at half yearly intervals).
2a	=	Nitrophoska 12:12:17:2 + TE applied at rate a (50g per shrub at half yearly intervals).
2b	=	Ibid but at rate b (100g per shrub at half yearly intervals).
2c	=	Ibid but at rate c (200g per shrub at half yearly intervals).

Each treatment was replicated 5 times.

Planting holes of dimension 0.5m × 0.5m × 0.5m were made and backfilled with a sandy clay loam topsoil premixed with treated sludge in the ratio 3:1 v/v (topsoil : sludge). Uniform plants of each species were laid out in a randomized block design under the appropriate shade regime, 1.5m apart from one another. Plants were left to establish for two weeks before fertilizer treatment was initiated. Similar to routine field fertilizer application, fertilizer was broadcasted around the plants at a safe distance from the trunk to avoid burn injury.

The trial was conducted for a year. A regular pest control programme was maintained throughout the trial period. Snails were the most damaging pest but these were kept at bay with 'Snailex'. Whenever necessary, trees were pruned to maintain the shade conditions required.

After 1 year, trial plants were harvested, washed with a non-ionic detergent and finally rinsed with distilled water. Dry matter accumulations were determined and recently matured leaves separated for the analysis of the N, P and K contents. Composite soil samples comprising three 0–6'' soil cores were collected for the analysis of total N, Bray P and ammonium acetate exchangeable K.

Total N was determined by the micro-Kjeldahl method, phosphorus by the molybdenum blue method and potassium by flame photometry (Anonymous, 1980; Chapman & Pratt, 1961; Hesse, 1971).

Results and Discussions

Results were statistically analysed by the Duncan Multiple Range Test and tabulated (Tables 2–7).

Irrespective of the shade regimes and the attendant plants investigated, there was no apparent relationship between dry matter yield and fertilization. With *Aglaonema pseudobracteatum* (Table 3), *Polyscias filicifolia* (Table 4) and *Ptychosperma macarthurii* (Table 6), treatment 2c (12:12:17:2 + TE at 200g per shrub at half yearly intervals) appear to have retarded early growth.

The N and K contents in the soil did not increase consistently with higher fertilizer rates probably partially due to leaching and run-off losses. However, in some cases, the soil P content was found to increase significantly with increasing fertilizer rates (Tables 3 & 6). P accumulation in the soil was probably due to its low mobility in the soil and low consumption by the plants.

Foliar N, P and K contents did not reflect the levels of these elements in the soil i.e. higher levels of such elements in the soil did not necessarily lead to their greater accumulation in the leaves.

Regardless of shade intensities, trial plants, fertilizer types and rates of application, the untreated controls appeared to perform similarly as the treated counterparts both visually and based on dry matter accumulation (Tables 2–7). The findings of the present investigation indicate that the fertilizer requirements for the early growth of ornamental shade shrubs were low. As a corollary, Othieno (1983) reported that the N, P and K contents of mature tea leaves were reduced under shade. The nutrient needs of shade shrubs appeared to be adequately met by the nutrient elements furnished by the sludge incorporated initially into the topsoil.

Conclusion

Shade-loving shrubs could maintain healthy growth on topsoil supplemented with sludge. Additional inorganic fertilizer did not further enhance growth in the first year. At higher rates, inorganic fertilizer could become detrimental to plant growth.

Table 2

Dracaena surculosa punctulata (Dense shade)

Treatment	C	1a	1b	1c	2a	2b	2c
Dry matter (g)	6.72d	2.94d	5.91d	5.06d	6.52d	5.74d	6.65d
Foliar N (%)	2.42e	1.81e	2.19e	2.69e	2.47e	2.55e	1.63e
Foliar P (%)	0.06f	0.09f	0.11f	0.19f	0.10f	0.13f	0.13f
Foliar K (%)	2.43g	2.42g	3.30g	4.15g	2.74g	4.54g	2.82g
Soil Total N (%)	0.31h	0.39h	0.37h	0.34h	0.37h	0.42h	0.43h
Soil Available P (ppm)	270j	606j	458j	1062j	590j	785j	579j
Soil Exchangeable K(me%)	0.25k	0.26k	0.39k	0.33k	0.28k	0.25k	0.31k

The treatments have reference in Table 1.

Values are means of 5 replicates.

Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P < 0.05$.

Table 3

Aglaonema pseudobracteatum (Dense shade)

Treatment	C	1a	1b	1c	2a	2b	2c
Dry matter (g)	12.14d	11.15d	11.29d	11.86d	9.22d	12.76d	8.82d
Foliar N (%)	2.34e	2.06e	2.72e	1.72e	2.27e	3.14e	2.25e
Foliar P (%)	0.32f	0.43f	0.41f	0.27f	0.27f	0.36f	0.38f
Foliar K (%)	5.93g	5.75g	5.60g	4.92g	5.48g	5.65g	5.81g
Soil Total N (%)	0.25h	0.37h	0.43h	0.33h	0.36h	0.34h	0.40h
Soil Available P(ppm)	157j	545j	882j	1405k	435j	907jk	904jk
Soil Exchangeable K(me%)	0.30ln	0.33lm	0.25l	0.57mn	0.24l	0.33lm	0.60m

The treatments have reference in Table 1.

Values are means of 5 replicates.

Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P < 0.05$.

Table 4
Polyscias filicifolia (Medium shade)

Treatment	C	1a	1b	1c	2a	2b	2c
Dry matter (g)	26.19ef	54.44d	44.55df	31.07ef	41.03dfg	32.27ef	20.93eg
Foliar N (%)	2.66h	2.58h	3.12h	2.44h	2.86h	2.76h	2.81h
Foliar P (%)	0.33j	0.22j	0.17j	0.18j	0.18j	0.26j	0.13j
Foliar K (%)	3.90k	3.68k	2.75km	3.78k	3.88k	3.44km	2.45lm
Soil Total N (%)	0.32n	0.31n	0.29n	0.33n	0.28n	0.33n	0.28n
Soil Available P(ppm)	428p	315p	248p	372p	609p	521p	238p
Soil Exchangeable K(me%)	0.18q	0.20q	0.20q	0.36q	0.26q	0.24q	0.26q

The treatments have reference in Table 1.

Values are means of 5 replicates.

Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P < 0.05$.

Table 5
Philodendron selloum (Medium shade)

Treatment	C	1a	1b	1c	2a	2b	2c
Dry matter (g)	29.36d	30.60d	33.68d	23.74d	16.53d	35.35d	45.00d
Foliar N (%)	3.15e	2.77e	3.55e	2.06e	4.06e	2.53e	1.97e
Foliar P (%)	0.20f	0.30f	0.24f	0.24f	0.31f	0.29f	0.27f
Foliar K (%)	3.21g	3.30g	3.41g	3.94g	4.11g	3.29g	3.22g
Soil Total N (%)	0.34h	0.35h	0.28h	0.34h	0.31h	0.50h	0.32h
Soil Available P(ppm)	1016j	1238j	934j	1520j	931j	1734j	1380j
Soil Exchangeable K(me%)	0.30k	0.41k	0.36k	0.37k	0.36k	0.39k	0.38k

The treatments have reference in Table 1.

Values are means of 5 replicates.

Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P < 0.05$.

Table 6
Ptychosperma macarthurii (Light shade)

Treatment	C	1a	1b	1c	2a	2b	2c
Dry matter (g)	119.75d	136.75d	98.50d	115.75d	124.13d	126.25d	89.88d
Foliar N (%)	2.44e	2.39e	2.51e	2.32e	2.10e	2.81e	2.26e
Foliar P (%)	0.15f	0.15f	0.13f	0.18f	0.14f	0.16f	0.14f
Foliar K (%)	1.69g	1.83g	1.94g	1.92g	1.84g	1.78g	1.74g
Soil Total N (%)	0.31h	0.35h	0.39h	0.34h	0.34h	0.28h	0.31h
Soil Available P(ppm)	231j	381jm	920kl	1051k	523jlm	472jlm	790km
Soil Exchangeable K (me%)	0.30n	0.37n	0.34n	0.44n	0.39n	0.44n	0.42n

The treatments have reference in Table 1.

Values are means of 5 replicates.

Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P < 0.05$.

Table 7
Ixora javanica (Light shade)

Treatment	C	1a	1b	1c	2a	2b	2c
Dry matter (g)	123.67d	136.17d	114.83d	85.33d	111.67d	102.17d	101.33d
Foliar N (%)	1.93e	2.44e	1.71e	1.54e	2.01e	1.50e	2.11e
Foliar P (%)	0.19f	0.13f	0.13f	0.13f	0.15f	0.13f	0.17f
Foliar K (%)	1.97g	2.19g	2.09g	2.05g	2.14g	2.00g	2.00g
Soil Total N (%)	0.36h	0.39h	0.31h	0.33h	0.34h	0.33h	0.29h
Soil Available P(ppm)	229j	325jk	543kl	494jk	285jl	614k	621k
Soil Exchangeable K(me%)	0.32m	0.31m	0.35m	0.40m	0.37m	0.50m	0.51m

The treatments have reference in Table 1.
Values are means of 5 replicates.
Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P < 0.05$.

This study tends to suggest that if sludge is used in the planting mix for shade shrubs, the latter can thrive well for the first year without any supplement of inorganic fertilizer. However, their long-term fertilizer requirements need to be elucidated by further field experimentation.

Literature Cited

Anonymous. (1980). Handbook on reference methods for soil testing. The Council on Soil Testing and Plant Analysis, University of Georgia, USA.

Chapman, H.D. and Pratt, P.F. (1961). Methods of analysis for soils, plants and waters. Division of Agricultural Sciences, University of California, USA.

Fails, B.S., Lewis, A.J. and Barben, J.A. (1982a). Net photosynthesis and transpiration of sun- and shade-grown *Ficus benjamina* leaves. *J. Amer. Soc. Hort. Sci.*, 107, 758–761.

Ibid. (1982b). Anatomy and morphology of sun- and shade-grown *Ficus benjamina. J. Amer. Soc. Hort. Sci.*, 107, 754–757.

Ibid. (1982c). Light acclimatization potential of *Ficus benjamina. J. Amer. Soc. Hort. Sci.*, 107, 762–766.

Hesse, P.R. (1971). A textbook of soil chemical analysis. William Clowes & Sons Limited, London.

Khatamian, H. and Lumis, G.P. (1982). Influence of shade, media and fertility on growth of *Taxus. J. Arbor.*, 8, 247–249.

McClendon, J.H. and McMillen, G.G. (1982). The control of leaf morphology and the tolerance of shade by woody plants. *Bot. Gaz.*, 143, 79–83.

Othieno, C.O. (1983). Studies on the use of shade in tea plantations in Kenya. I. Effects of nutrient uptake and yield of tea — Preliminary results. *Tea,* 4, 13–20.

Smith, E.M. and Treaster, S.A. (1981). Fertilizing trees in the landscape: A 9-year evaluation. Ohio Agricultural Research and Development Center, *Research Circular* 263, 11–13.

van de Werken, H. (1981). Fertilizing and other factors enhancing the growth rate of young shade trees. *J. Arbor.* 7, 33–37.

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SINGAPORE

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Six New Species of *Bulbophyllum* Sect. *Monilibulbus* (Orchidaceae)

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Drawings by J.J. Vermeulen

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Abstract

Six new species of *Bulbophyllum* sect. *Monilibulbus* (Orchidaceae) from Borneo are described: *B. kestron, B. leproglossum, B. nubinatum, B. pelicanopsis, B. scabrum* and *B. thymophorum*. Full descriptions and detailed line drawings are presented of each species. Possible relationships of sect. *Monilibulbus* within the genus *Bulbophyllum* are pointed out.

Introduction

The approximately 50 species of *Bulbophyllum* sect. *Monilibulbus* J.J. Smith range from China (Yunnan), Indochina, Malaysia, Philippines to W. Indonesia (eastwards up to Celebes and the Lesser Sunda Islands). As with most other sections within *Bulbophyllum*, sect. *Monilibulbus* has never been subject to revision. Only enumerations for comparatively small areas within its range have been published: Thailand (Seidenfaden, 1979), West Malaysia (Holttum, 1957) and Java (Smith, 1905). Many more species (often not even recognized as pertaining to sect. *Monilibulbus*) have been described in numerous papers by Smith, Schlechter and Ames, as parts of endless enumerations of new orchid species.

Within the large genus *Bulbophyllum* the species of sect. *Monilibulbus* can be recognized by the following set of characters:

Rhizome creeping. Pseudobulbs distinct, approx. close together, (occasionally widely spaced in *B. inaequale* (Bl.) Lindl.), obliquely reclining and covering or even partly enveloping the subsequent section of rhizome for most of their length, only the very top more or less erect (pseudobulbs distinctly dorsoventrally flattened but not particularly oblique in *B. moniliforme* Par. & Rchb. f.), with one leaf. Inflorescence with one flower. Pedicel with an extra node close to its base.

Sect. *Monilibulbus* is a West Malesian (Van Steenis, 1948: p. XI) element. The combination of characters mentioned distinguishes the section. Elsewhere within *Bulbophyllum* all these characters occur as well, but always in different combinations. They can be found in particular in species belonging to sections which have a mainly East Malesian (New Guinea and surrounding archipelagos) distribution and which have one-flowered inflorescences. The sections *Fruticicola* Schltr, *Epibulbon* Schltr and *Leptopus* Schltr (see Schlechter, 1911–1914) can be mentioned as examples.

The flowers of sect. *Monilibulbus*, although often of a peculiar structure, do not have a single character in common. Here, too, morphological similarities with E. Malesian sections exist, in particular with the sections *Leptopus* Schltr and *Brachypus* Schltr (see Schlechter, 1911–1914).

Among the sections with a one-flowered inflorescence, sect. *Monilibulbus* has a distinctly aberrant range. Most sections with a one-flowered inflorescence are mainly East Malesian, with only few representatives in West Malesia. Examples are sect. *Fruticicola* Schltr, with many species in New Guinea and very few in West Malesia (e.g. *B. perductum* J.J. Smith on Java and an undescribed species on Borneo), and sect. *Polyblepharon* Schltr with numerous species in New Guinea and only few species in W. Malesia (e.g. the widespread *B. tortuosum* (Bl.) (Lindl.).

Few sections with one-flowered inflorescences have an approximately equal number of species occurring in West and East Malesia, e.g. sect. *Sestochilus* (Breda) Benth. & Hook. f. The numbers of species belonging to this section described for Thailand (Seidenfaden, 1979) or West Malaysia (Holttum, 1957) or New Guinea (Schlechter, 1911–1914) are of comparable magnitude.

Sect. *Monilibulbus* is the only section in which a one-flowered inflorescence is combined with an exclusively West Malesian distribution.

Perhaps not supported by distribution patterns, but consistent with shared vegetative and floral characters, a close relationship of sect. *Monilibulbus* to East Malesian sections is suggested, particularly to sect. *Brachypus* Schltr, *Epibulbon* Schltr, *Fruticicola* Schltr and *Leptopus* Schltr.

Basic to this statement are two assumptions.

Firstly, sect. *Monilibulbus* should be a natural (monophyletic) group, i.e. a group of species derived from a single ancestor species. Crucial for recognizing a monophyletic group is that the species of the group share a number of characters which can be considered derived within the group. *Monilibulbus* has a set of characters shared by (almost) all its species. Unfortunately, without further phylogenetic analysis one can only guess whether or not these are derived.

Secondly, within *Bulbophyllum* the character state 'many-flowered inflorescence' should be primitive, and the state 'one-flowered inflorescence' derived. This is very likely, considering the fact that in most genera which may serve as the hypothetical immediate ancestor of *Bulbophyllum* (other genera of Denbrobieae sensu Burns-Balogh & Funk, 1986) most species have many-flowered inflorescences.

Some species of sect. *Monilibulbus* are very variable, particularly *B. ovalifolium* (Bl.) Lindl. The new species *B. kestron, B. leproglossum* and *B. scabrum* all occur within the geographical range of *B. ovalifolium* and show a distinct similarity to races of that species. Before describing them as new species the variability of *B. ovalifolium* has been surveyed extensively. The characters of the new species distinguishing them from *B. ovalifolium* are mentioned under the description of each of them.

The other three species *B. nubinatum, B. pelicanopsis* and *B. thymophorum* each have one or more outstanding features, which immediately distinguish them from other species of sect. *Monilibulbus.*

Colour slides of all six new species have been published in Vermeulen & Lamb (1988).

Description of the New Species

Bulbophyllum kestron J.J. Vermeulen & A. Lamb, *sp. nov.* Fig. 1.

Bulbophyllo ovalifolio affinis, labelli margine denticulato-lacerato differt. *Type:* Borneo; *Lamb 566/86* (K!).

Rhizome creeping, 0.6 mm diam. Pseudobulbs 0.2–0.5 cm apart, ovoid, somewhat flattened, 0.2–0.5 × 0.2–0.4 cm. Petiole 0.8–2 mm long. Leaves rather thin, elliptic to (ob-)ovate, 0.5–1.7 × 0.2–0.5 cm, index 2.5–4. Inflorescence 2.5–4 cm long, 1-flowered. Peduncle 1.8–2.5 cm. Floral bracts tubular, c. 1.5 mm long. Pedicel and ovary 5–14 mm long. Median sepal thin, elliptic to obovate, 2.5–6 × 1.5–2.5 mm, index 1.6–2.5, tip rounded, margins finely papillose, surface glabrous. Lateral sepals free, ovate to elliptic, 3.8–6 × 2–3.5 mm, index 1.5–2.5, otherwise as the median. Petals thin, obovate, 1.2–1.9 × 0.7–1.2 mm, index 1.5–2, tip rounded, margins erose towards the tip, surface glabrous. Lip recurved, rather thick, c. elliptic, 1–2.8 × 0.8–1.5 mm, adaxially with 2 keels in the basal part, tip rounded, margins dentate-lacerate c. half way, surface with large, often flattened, rounded to truncate appendages. Column 0.4–1.2 mm long. Stelidia triangular, 0.15–0.7 mm long, with a distinct, obtuse tooth along the lower margin. Stigma with a rather inconspicuous basal callus. Pollinia 4, of unequal size. Stipes absent.

Colours: Sepals bright orange to salmon red, or green, suffused with dark red. Petals pale yellowish to pale orange red, occasionally with somewhat reddish purple top part and midvein. Lip (dull) dark red or red purple, occasionally yellow near base. Column pale yellow with some purple.

Habitat and Ecology: One observation: high and wet montane forest, on the bole of a large tree. Growing on bark covered with algae or fine moss. Alt. 1500–2000 m. Flowers not scented. Flowering May–July and October.

Distribution: Sabah. West Coast Z./Interior Z.: G. Kinabalu; Crocker Range.

General Distribution: Borneo.

Notes: B. kestron is morphologically close to *B. ovalifolium* (Bl.) Lindl. but can be distinguished when looking at the margins of the lip: in *B. kestron* it is denticulate-lacerate about half way the lip where the margins curve downwards, whereas in *B. ovalifolium* it is always entire or at most somewhat irregular.

Some specimens of *B. kestron* have a relatively larger lip (compared to the lateral sepals) than the Bornean specimens of *B. ovalifolium.*

The various ornamentations on the lip (ridges and verrucae) may vary conspicuously in *B. kestron.* When more material becomes available probably it will show a wide range of variation on this point, similar to that in *B. ovalifolium.*

The name is derived from the word 'kestros' which means: rough of tongue.

Bulbophyllum leproglossum J.J. Vermeulen & A. Lamb, *sp. nov.* Fig. 2.

Bulbophyllo ovalifolio affinis, labelli latere adaxiali duobus locis rugosis differt. *Type:* Borneo; *Vermeulen 584* (L!).

Rhizome creeping, 0.8 mm diam. Pseudobulbs 0.3–0.7 cm apart, ovoid, flattened, 0.3–0.7 × 0.2–0.4 cm. Petiole 0.5–1 mm long. Leaves rather thick, elliptic to obovate, 0.7–2.4 × 0.4–0.7 cm, index 1.6–3.5. Inflorescence c. 6.5 cm long, 1-flowered. Peduncle 4.5 cm. Floral bracts tubular, c. 2 mm long. Pedicel and ovary 22 mm long. Median sepal thin, ovate, c. 6.5 × 1.8 mm, index c. 3.5, tip acute, c. glabrous. Lateral sepals free, c. 11 × 4 mm, index 3.7, margins somewhat erose, otherwise as the median. Petals thin, elliptic, c. 2.4 × 1 mm, index c. 2.4, tip acute, glabrous. Lip recurved, rather thin, ovate, c. 3.6 × 1.6 mm, tip rounded, margins somewhat erose, surface glabrous except for two rugose patches adaxially towards the margins in the lower half. Column c. 2 mm long. Stelidia subulate, c. 1 mm long, with rather inconspicuous, obtuse teeth along the upper as well as the lower margin. Stigma with a distinct, obtuse basal callus. Pollinia 2. Stipes absent.

Colours: Median sepal translucent white with red veins. Lateral sepals white with red veins. Lip dark red purple.

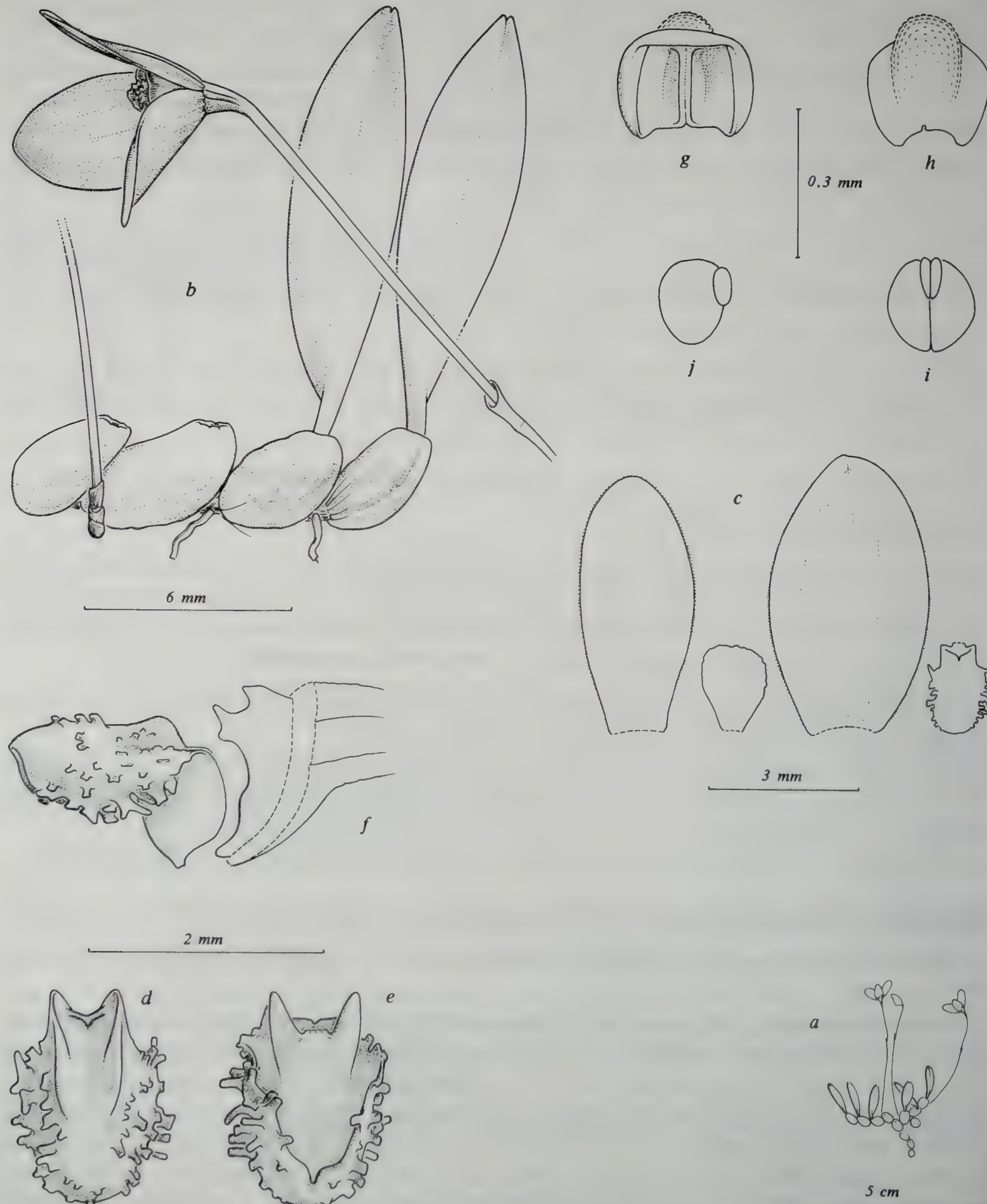

Fig. 1. *B. kestron.* a — habit; b — part of plant; c — flower analysis. From left to right: median sepal, petal, lateral sepal, lip; d — lip, adaxial side; e — lip, abaxial side; f — column and lip, lateral view; g — anther, adaxial side; h — anther, abaxial side; i — pollinia. Drawn from type specimen.

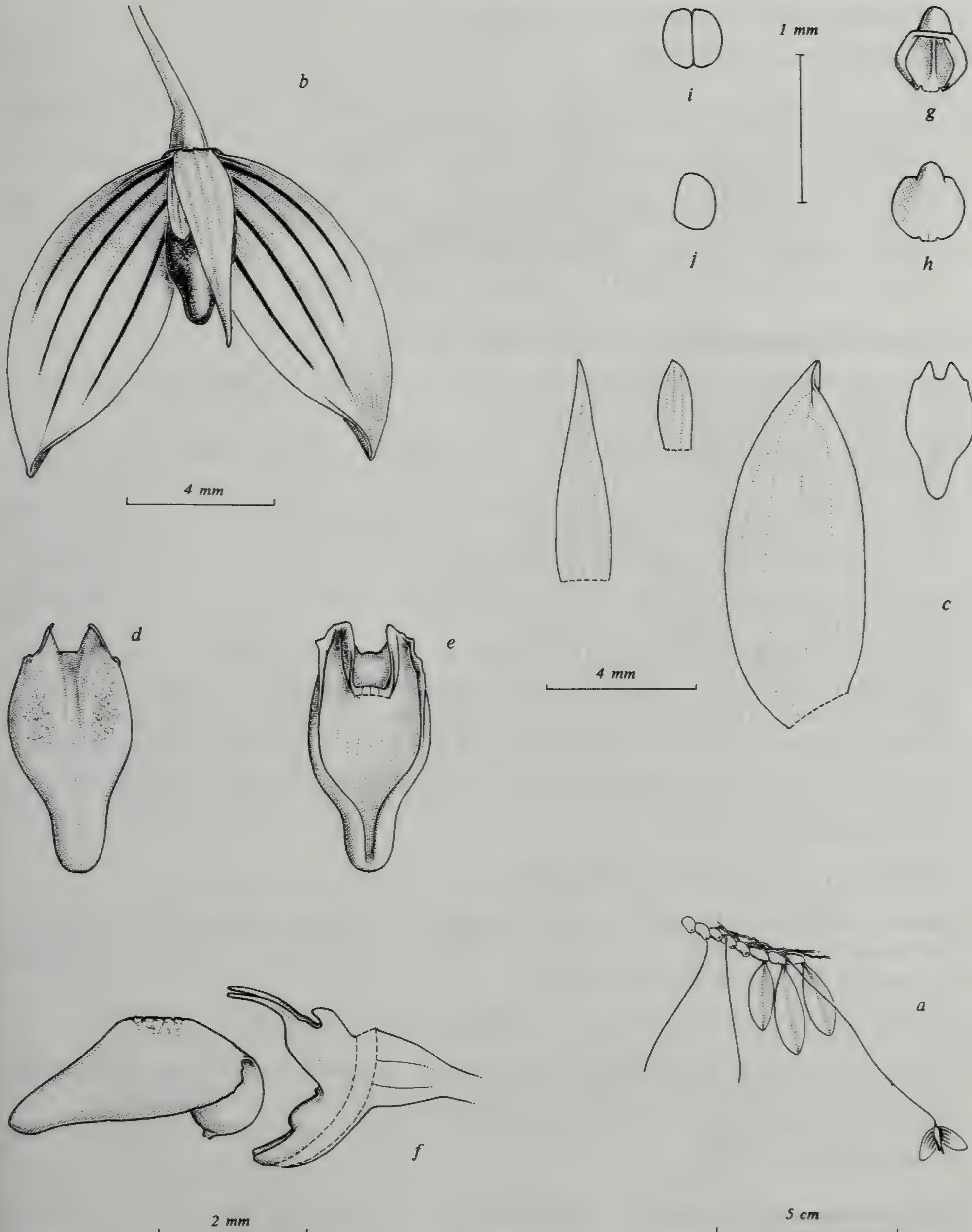

Fig. 2. *B. leproglossum*. a — habit; b — flower; c — flower analysis. From left to right: median sepal, petal, lateral sepal, lip; d — lip, adaxial side; e — lip, abaxial side; f — column and lip, lateral view; g — anther, adaxial side; h — anther, abaxial side; i — pollinia. Drawn from type specimen.

Habitat and Ecology: Found in high montane forest, on mossy branch of small tree. Alt. 1300–1500 m. Flowers not scented. Flowering observed in October.

Distribution: Sabah. Interior Z.: Ulu Padas.

General Distribution: Borneo.

Notes: *B. leproglossum* is a species close to *B. ovalifolium* (Bl.) Lindl. It can be distinguished by the general shape of the lip and in particular by the two patches of rough texture in the lower half of the lip (take care with shriveled herbarium specimens, in which these patches may not be very distinct). The colour, however characteristic it seems, is not diagnostic: similarly coloured specimens of *B. ovalifolium* have been found, be it only outside Borneo so far.

Its name has been derived from 'lepros': rough, glossa: tongue.

Bulbophyllum nubinatum J.J. Vermeulen, *sp. nov.* Fig. 3.

In sectione Monilibulbo floribus magnis, sepalis lateralibus 1–2.5 cm longis, labello gracilissimo distincta. *Type:* Borneo; *Chan 63/87* (Holo- L!, iso- K!, SNP!).

Rhizome creeping, 0.8–1 mm diam. Pseudobulbs 0.3–0.6 cm apart, ovoid to ellipsoid, flattened, 0.2–0.6 × 0.15–0.2 cm. Petiole 0.5–1 mm long. Leaves rather thin, ovate to elliptic, 0.6–2.2 × 0.2–0.6 cm, index 2–8. Inflorescence c. 7 cm long, 1-flowered. Peduncle c. 5 cm. Floral bracts tubular, 2.2–3 mm long. Pedicel and ovary 8–15 mm long. Median sepal thin, ovate, 9–21 × 1–3 mm, index 7–16, tip subacute, glabrous. Lateral sepals free, 10–20.5 × 1.5–2.8 mm, index 4–13, otherwise as the median. Petals thin, elliptic to obovate, 1.5–4 × 0.7–1.5 mm, index 2–2.5, tip obtuse to acute, margins glabrous to coarsely erose, surface glabrous. Lip recurved, rather thick, c. ovate with a slightly widened top part (c. elliptic when spread), 2.8–5.5 × 0.9–1.2 mm, with a callus towards the base which is thickest along the margins, tip obtuse, margins somewhat erose towards the tip and the base, surface glabrous. Column 0.7–1 mm long. Stelidia inconspicuous, deltoid, obtuse, without teeth along the upper or lower margins. Stigma with a small toothlike callus at the base. Pollinia 2. Stipes absent.

Colours: Flowers entirely (orange) yellow.

Habitat and Ecology: Upper montane *Dacrydium-Leptospermum* forest; upper montane forest on ultrabasic soil. Alt. 2000–3000 m. Flowers not scented. Flowering observed in March, June and August.

Distribution: Sabah. West Coast. Z./Interior Z.: G. Kinabalu.

Notes: *B. nubinatum* is well characterized by the shape of the lip: long and narrow, with recurved margins half way and a flat, wider top part.

The name 'nubinatum', born in the clouds, refers to the high altitudes at which the species grows.

Bulbophyllum pelicanopsis J.J. Vermeulen & A. Lamb, *sp. nov.* Fig. 4.

In sectione Monilibulbo sepalis lateralibus ellipticis connatis et labello elliptico distincta. *Type:* Borneo; *Vermeulen 582* (L!). Plate 4.

Rhizome creeping, c. 0.6 mm diam. Pseudobulbs 0.15–0.6 cm apart, ellipsoid, flattened, 0.15–0.6 × 0.15–0.22 cm. Petiole 0.2–0.3 mm long. Leaves rather thin, ovate, 0.3–0.4 × 0.25–0.3 cm, index 1–1.5. Inflorescence 1–1.2 cm long, 1-flowered. Peduncle 0.7 cm. Floral bracts tubular, 0.8–1 mm long. Pedicel and ovary 2–3 mm long. Median sepal thin with distinctly thickened top part, obovate-spathulate, 2.5–4.2 ×

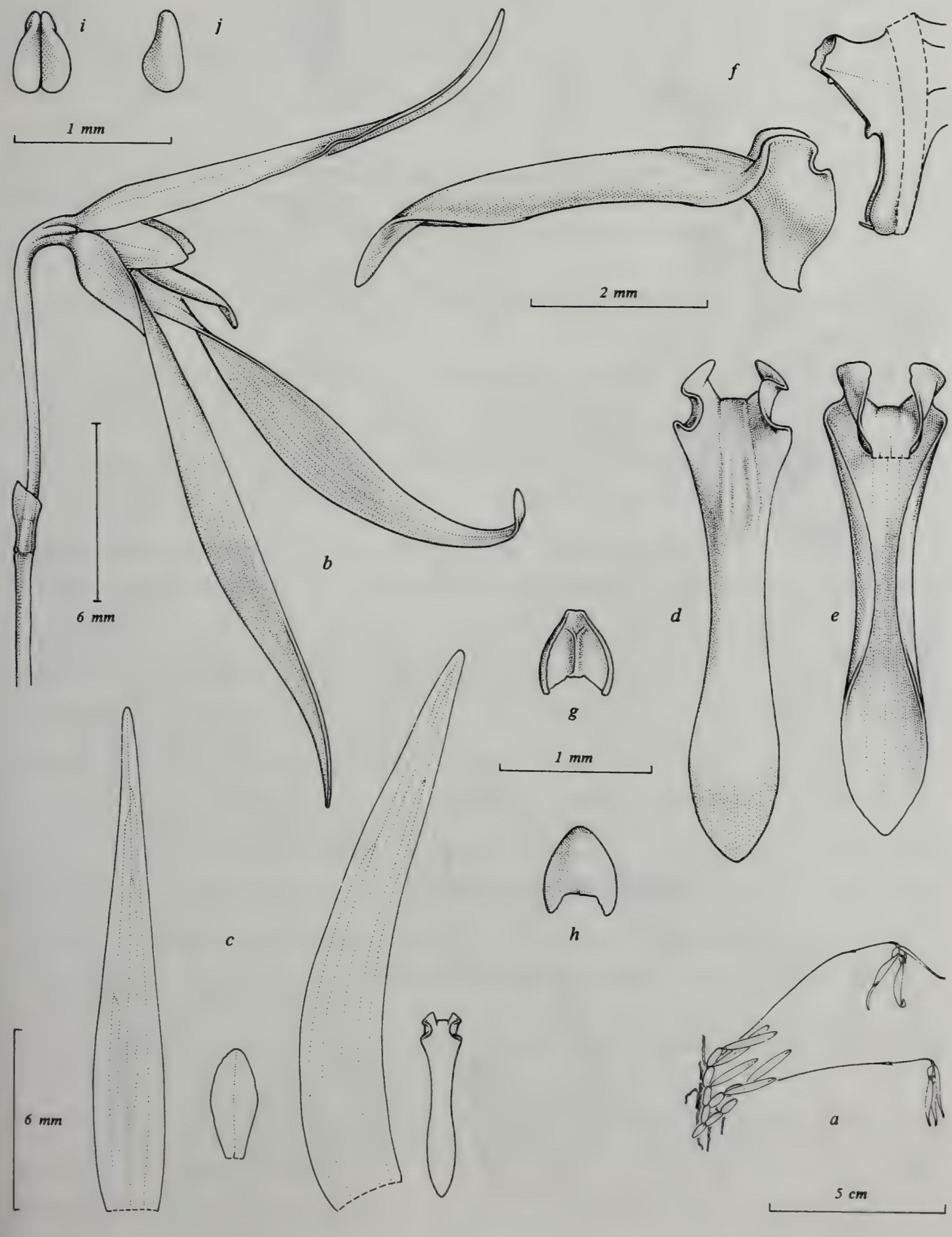

Fig. 3. *B. nubinatum*. a — habit; b — flower; c — flower analysis. From left to right: median sepal, petal, lateral sepal, lip; d — lip, adaxial side; e — lip, abaxial side; f — column and lip, lateral view; g — anther, adaxial side; h — anther, abaxial side. Drawn from type specimen.

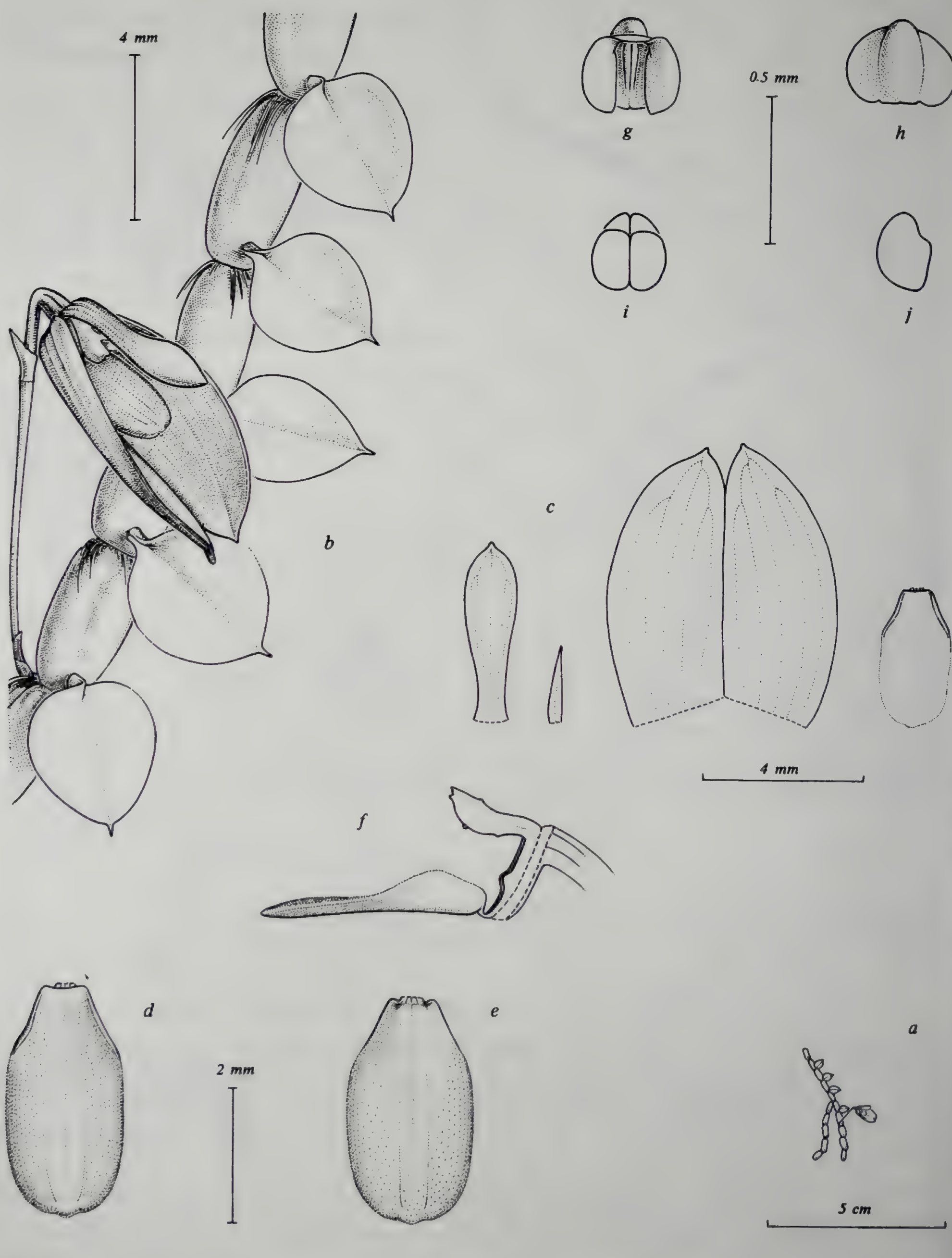

Fig. 4. *B. pelicanopsis.* a — habit; b — part of plant; c — flower analysis. From left to right: median sepal, petal, lateral sepal, lip; d — lip, adaxial side; e — lip, abaxial side; f — column and lip, lateral view; g — anther, adaxial side; h — anther, abaxial side; i — pollinia. Drawn from type specimen.

1–1.4 mm, index 2.5–3, tip rounded to subacute, glabrous. Lateral sepals adnate, thin, elliptic, 4–7 × 2–3 mm, index 2–2.5, tip cuspidate, glabrous. Petals thin, ovate, 1–2 × c. 0.3 mm, index 3.3–7, tip acute, glabrous. Lip not recurved, thin, elliptic, 2.2–3.2 × 1.5–2 mm, tip rounded, almost entirely finely papillose. Column 1–1.5 mm long. Stelidia inconspicuous, deltoid, obtuse, without teeth along the upper or lower margins. Stigma without basal callus. Pollinia 2. Stipes absent.

Colours: Median sepal pale yellow, brownish orange at the tip. Lateral sepals, petals and lip white.

Habitat and Ecology: Observed in high montane *Agathis-Lithocarpus* forest on a ridge, on the bole of a large tree, near the forest floor. Growing among fine moss of exactly the same colour. Alt. 1200–1500 m. Flowers not scented. Flowering observed in October.

Distribution: Sabah. West Coast Z./Interior Z.: G. Kinabalu; Crocker Range; Ulu Padas.

Notes: Within sect. *Monilibulbus, B. pelicanopsis* shares the connate lateral sepals with *B. connatum* Carr. It can be distinguished by the acute, not caudate lateral sepals. Unique in *B. pelicanopsis* is the spathulate median sepal.

The name 'pelicanopsis', 'like a pelican' is given because the flowers look like the head of a pelican, with a narrow upper beak and a much wider lower one.

Bulbophyllum scabrum J.J. Vermeulen & A. Lamb, *sp. nov.* Fig. 5.

Bulbophyllo phaeoneuron similis, sepalis latere abaxiali et marginibus papillosis insigne. *Type:* Borneo; *Vermeulen 483* (L!).

Rhizome creeping, c. 1 mm diam. Pseudobulbs 0.25–0.5 cm apart, ellipsoid to orbicular, somewhat flattened, 0.25–0.5 × 0.25–0.5 cm. Petiole 0.2–0.5 mm long. Leaves thick, ovate to elliptic, 0.5–1.8 × 0.4–0.5 cm, index 1.2–3.6. Inflorescence 1 cm long, 1-flowered. Peduncle 0.3 cm. Floral bracts tubular, c. 2 mm long. Pedicel and ovary c. 4.5 mm long. Median sepal rather thin, ovate to elliptic, c. 4 × 3.2 mm, index c. 1.2, tip cuspidate, margins papillose, abaxial surface irregularly papillose. Lateral sepals free, rather thick, ovate, 4 × 3.4 mm, index c. 1.2, margins somewhat erose, papillose, otherwise as the median. Petals thin, ovate, c. 1 × 1 mm, index c. 1, tip subacute, glabrous. Lip with a recurved top part, very thick, obovate, c. 2.3 × 1.6 mm, adaxially with 2 short, rounded keels near the base, tip rounded, glabrous. Column 0.8 mm long. Stelidia triangular, 0.2 mm long, without teeth along the margins. Stigma with a large basal callus. Pollinia 4, of unequal size. Stipes absent.

Colours: Median sepal and petals translucent with orange veins. Lateral sepals bright orange red. Lip dark red. Column greenish.

Habitat and Ecology: One observation: Montane Fagaceae-*Dacrydium-Leptospermum* forest, growing in dense mats on a large branch. Alt. 1500 m. Flowers not scented. Flowering observed in October.

Distribution: Sabah. West Coast Z./Interior Z.: G. Kinabalu.

Notes: B. scabrum is characterized by the very short inflorescence, just as *B. phaeoneuron* Schltr from Sumatra and Borneo. It differs from this species in the partly papillose sepals and in the shape of the lip which is gradually recurved towards the tip and which has distinctly sinuose margins. Some specimens of *B. ovalifolium* (Bl.)

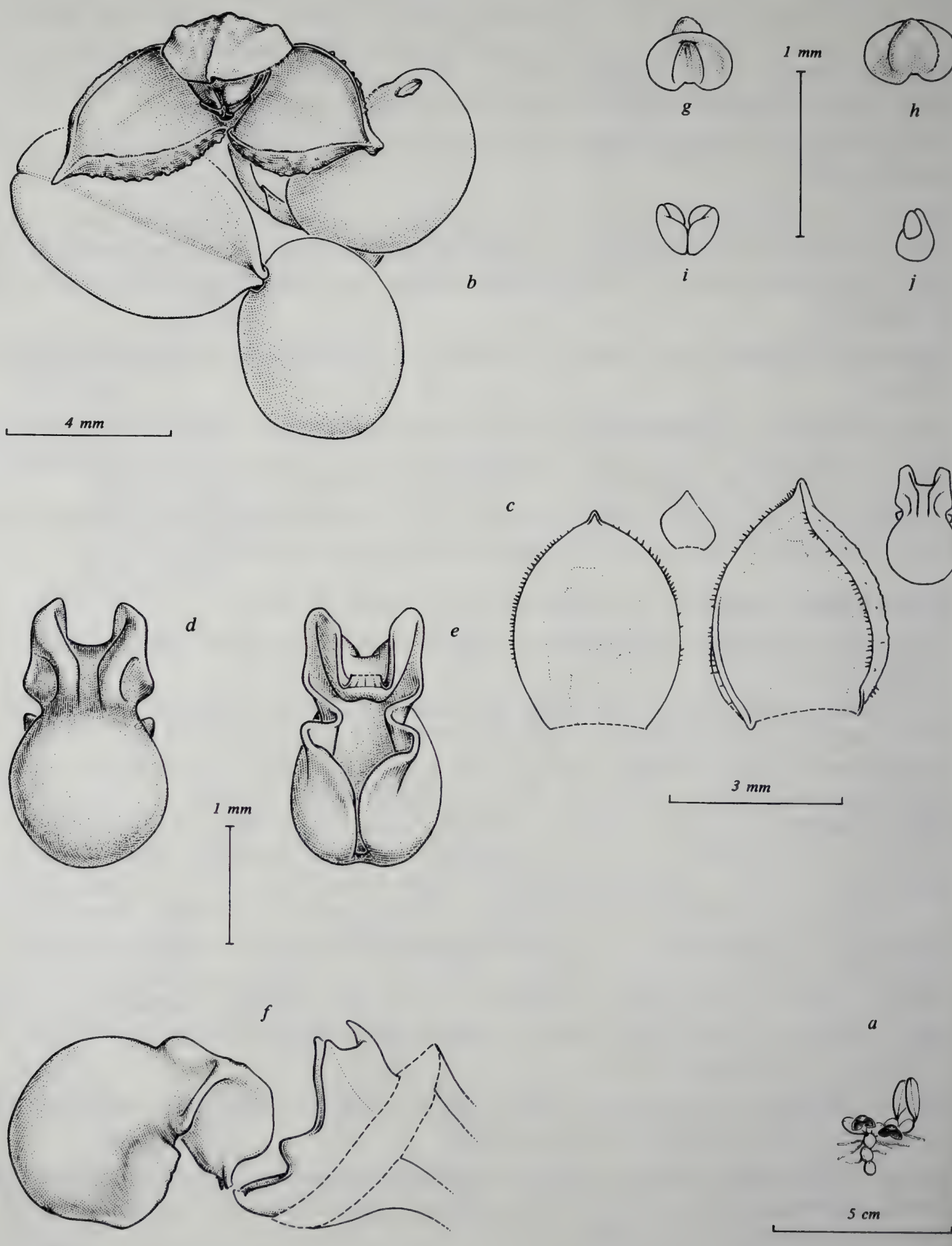

Fig. 5. *B. scabrum.* a — habit; b — part of plant; c — flower analysis. From left to right: median sepal, petal, lateral sepal, lip; d — lip, adaxial side; e — lip, abaxial side; f — column and lip, lateral view; g — anther, adaxial side; h — anther, abaxial side; i — pollinia. Drawn from type specimen.

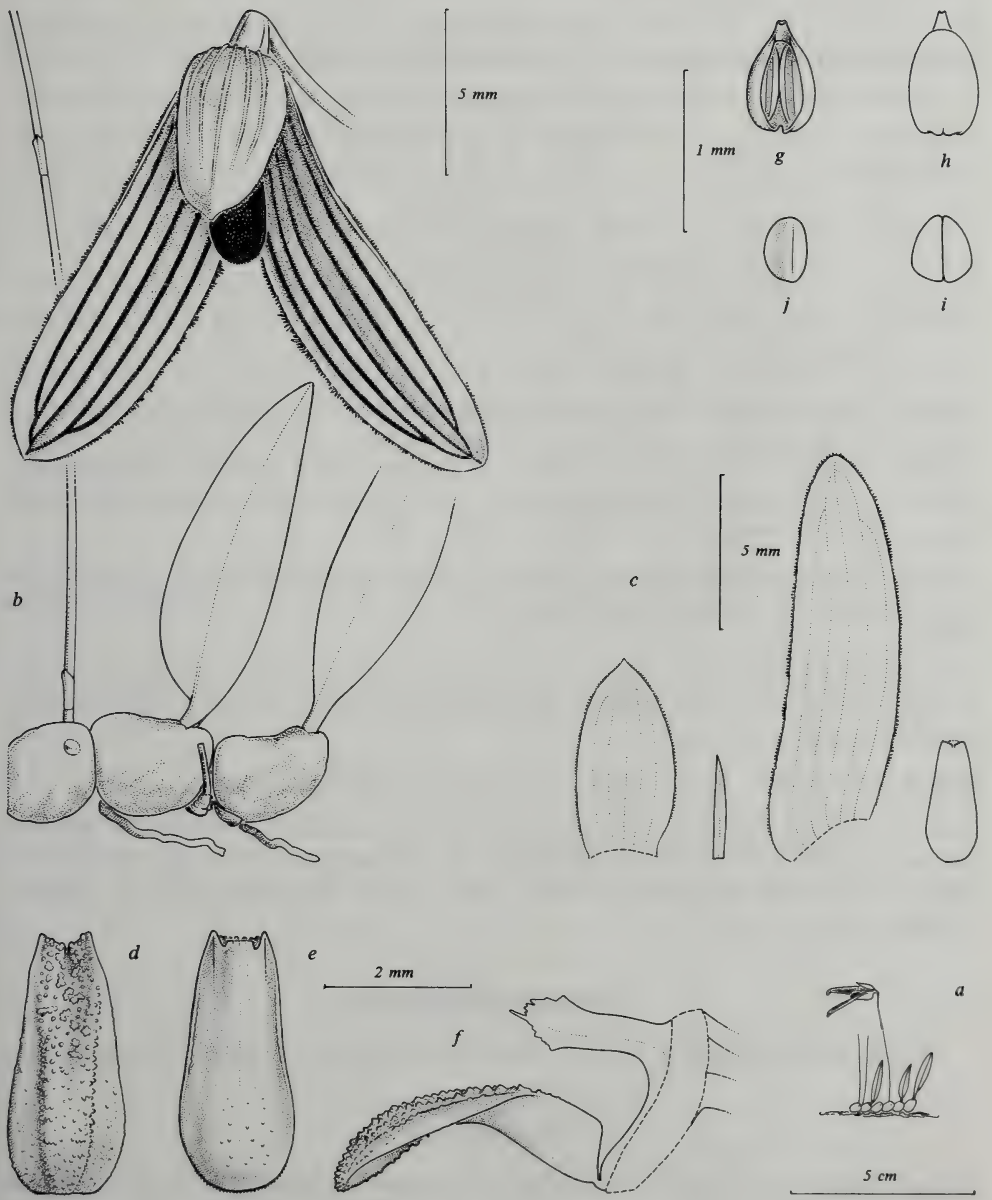

Fig. 6. *B. thymophorum*. a — habit; b — part of plant; c — flower analysis. From left to right: median sepal, petal, lateral sepal, lip; d — lip, adaxial side; e — lip, abaxial side; f — column and lip, lateral view; g — anther, adaxial side; h — anther, abaxial side; i — pollinia. Drawn from type specimen.

Lindl., a species which has been found on Borneo as well, have lips with similarly sinuose margins but a much longer inflorescence.

The name 'scabrum', 'rough' is given because of the papillose margins and abaxial surface of the sepals.

Bulbophyllum thymophorum J.J. Vermeulen & A. Lamb, *sp. nov.* Fig. 6.

In sectione Monilibulbo labelli vitta centrali paulo elata distincta. *Type:* Borneo; *Lamb 564/86* (K!).

Rhizome creeping, c. 0.8 mm diam. Pseudobulbs 0.2–0.4 cm apart, ovoid, somewhat flattened, 0.2–0.4 × 0.25–0.35 cm. Petiole 0.6–1 mm long. Leaves rather thin, ovate to elliptic, 0.9–1.5 × 0.2–0.35 cm, index 3–4. Inflorescence 3–3.5 cm long, 1-flowered. Peduncle 2.1–2.8 cm. Floral bracts tubular, c. 2 mm long. Pedicel and ovary 9–12 mm long. Median sepal thin, ovate, 5–5.8 × 2–3.4 mm, index 1.7–2.5, tip acuminate, margins finely erose, papillose, surface glabrous, abaxially somewhat papillose. Lateral sepals free, 11–13 × 2–3.8 mm, index 4–5.5, tip obtuse, otherwise as the median. Petals thin, elliptic, 2.2–3.1 × 0.2–0.3 mm, index 10–11, tip acute, glabrous. Lip somewhat recurved, rather thick, obovate, 2.8–3.8 × 0.8–1.5 mm, tip rounded, margins somewhat erose, adaxially with a slightly thickened median ridge towards the tip, surface coarsely verrucate along the median line, finely verrucate-papillose towards the margins. Column 2–2.2 mm long. Stelidia inconspicuous, rounded, margins deeply erose-denticulate, lower margin with a deltoid, acute tooth. Stigma without basal callus. Pollinia 2. Stipes absent.

Colours: Median sepal translucent white to orange, with orange veins. Lateral sepals almost white, veins brown purple. Petals white. Lip purple to very dark red. Column white.

Habitat and Ecology: High, wet or dry montane forest, on trunks and large branches of canopy trees. Alt. 1700–1900 m. Flowers with a faint, unpleasant smell. Flowering observed in June–July.

Distribution: Sabah. West Coast Z./Interior Z.: Crocker Range.

Notes: B. thymophorum can be recognized easily because of the slightly elevated, verrucose-papillose longitudinal strip over the median part of the lip, which is well separated from the much less textured lateral sides. The name refers to 'thymos' meaning wart.

Acknowledgements

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References

Burns-Balogh, P. & Funk, V.A. (1986). A Phylogenetic Analysis of the Orchidaceae. *Smithsonian Contributions to Botany* 61, 1–71.

Holttum, R.E. (1957). Orchids of Malaya. *Flora of Malaya I.* 2nd ed., 1–759.

Schlechter, R. (1911–1914). Die Orchidaceen von Deutsch Neu-Guinea. *Fedde, Rep., Beih. I.* 1–1041.

Seidenfaden, G. (1979). Orchid Genera in Thailand VIII: *Bulbophyllum. Dansk Bot. Ark.* 33: 7–228.

Smith, J.J. (1905). Die Orchideeen von Java. *Flora Buitenzorg 6.* 1–672.

Steenis, Van, C.G.G.J. (1948). Introduction to *Flora Malesiana* 1, 4, p. III–XII.

Vermeulen, J.J. & Lamb, A. (1988). *Bulbophyllum* — some interesting novelties from the Bornean jungle. *Mal. Orch. Rev.* 22. 44–47.

Three New Taxa in *Elaeocarpus* in the Malay Peninsula

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Abstract

Upon completion of a revision of the *Elaeocarpaceae* for the Tree Flora of Malaya Vol 4, which will be published in early 1989, two new species and a new variety were uncovered. These are *Elaeocarpus sallehiana, E. symingtonii* and *E. nitidus* var. *velutinus*, described below.

The total number of *Elaeocarpus* spp. recognised in the Peninsula now stands at 27 compared to the 26 in Ridley's Flora of the Malay Peninsula 1(1922) 308–321 and 31 in Corner's revision in the Gardens' Bulletin Straits Settlements 10(1939) 308–329.

Elaeocarpus sallehiana Ng *sp. nov.*

Arbor mediocris usque 30 alta, ambitu 1.2 m. Truncus in sectione interdum irregularis, interdum anteridibus angustis rectis usque 1 m altis. Cortex brunneus, laevis; stratura interiore rubro-brunnea. Lignum vivens album usque cremeum. Partes ramulorum foliaceorum 0.15–0.3 cm diametro; ramuli cum petiolis, faciebus foliorum inferioribus et inflorescentiis dense velutini; stipuli minutis, triangulares, caduci. Folia plus spiraliter quam alternatim disposita; laminae ovatae usque ellipticae, coriaceae, 4.8 × 2.3 – 12.5 × 5.5 cm, apice acuminato, basi cuneata, marginibus obscure dentatis, nervis secondariis 4–7 jugis, nervis tertiariis transversis; petioli 2–4 cm, leniter geniculati. Racemi 3–8 cm longi, plerumque in axillis foliorum etiam praesentium orti. Flores bracteis ± persistentibus villosis 0.3–1 cm longis subtenti, 5-meri; petala 0.3 cm longa; stamina 15; ovarium sericeum; pedicelli 0.2–0.3 cm longi. Fructus ellipsoidei usque obovoidei, in sicco durescentes, tenuiter pilosi, usque 2.2 × 1.9 cm.

Medium trees to 30 m tall. Similar to some variants of *E. stipularis* (which it resembles in the hairiness of the twigs, the deeply fimbriate petals and 5-locular ovary) but distinguishable in the absence of leafy stipules, presence of semipersistent bracts subtending the flowers, the fewer stamens (15, not 30–35), and the hairy fruits.

Distribution: Trengganu (*KEP 79597, FRI 2614, 10782, 12750, 12788*), Pahang (*FRI 15368*). In hill and mountain forests at 210–1070 m.

Holotype: FRI 12788 in Hb. KEP! Isotypes: K, L, SING, ARN.

The species is named after Dr. Salleh Mohd Nor, Director General of the Forest Research Institute Malaysia (Kepong).

Elaeocarpus symingtonii Ng *sp. nov.*

Arbor parva usque 7 m alta. Partes ramulorum foliaceorum 0.4–0.8 cm diametro, apicibus interdum resinosis. Laminae foliorum ellipticae usque oblongo-ellipticae, tenuiter coriaceae, 10 × 4 – 21 × 10 cm, glabrae, apice acuto usque acuminato, basi rotundata usque obtuse cuneata, dentibus marginis 1.5–4 per cm, nervis secondariis 8–12 jugis, nervis tertiariis reticulatis usque approximate transversis; petioli 6–14 cm longi, valde geniculati. Racemi 7–15 cm longi, in axillis foliorum etiam praesentium orti. Flores 4-meri; petala c. 0.5 cm longa; stamina c. 30; ovarium sericeum; pedicelli 0.6–0.9 cm longi. Fructus ignoti.

Small trees to 7 m tall.

Distribution: Perak (*FRI 6143*), Trengganu (*FRI 12091*), Pahang (*KEP 31009*), in summit forests at 1400 m and above.

Holotype: FRI 6143 in Hb KEP! Isotypes: K, L, SING, ARN.

This species is named after C.F. Symington, Forest Botanist at the Forest Research Institute (Kepong) before the Second World War.

E. nitidus Jack **var. velutinus** Ng *var. nov.*

Arbor mediocris, usque 21 m alta, ambitu 1.2 m, cum anteridibus rectis vel gralliformibus. A var. *nitido* foliis infra dense et minute velutinis, petiolis 1.5–4.5 cm longis, fructibus paullo longioribus quam latioribus.

Medium tree to 21 m tall, differing from the typical variety in the leaves densely finely velvety below (instead of glabrous) and the fruits a little longer than wide (instead of globose).

Distribution: Kelantan (*FRI 12464*), Pahang (*FRI 16594*), Johore (*FRI 12382*), in hill and mountain forests at 820–1528 m.

Holotype: FRI 12382 in Hb. KEP! Isotypes: K, L, SING.

Acknowledgements

I am grateful to Mr. M.J.E. Coode of the Royal Botanic Gardens, Kew, for the translation of my descriptions into botanical Latin.

A New Species of *Adiantum* from Trus Madi Range, Sabah

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Abstract

Adiantum lamrianum Aziz Bidin and Razali Jaman is described as a new species. It is found in undisturbed forest of Trus Madi Range, Sabah.

Introduction

The flora of Sabah has been of great interest among botanists since Hugh Low first reached the summit of Mount Kinabalu on 11 March 1851. Since then many more expeditions have been carried out mainly to collect plants along the trail to Kinabalu Peak. Among the notable accounts and collections were those of O. Stapf in 1894 (Cockburn, 1978); L. Gibbs and D.R. Maxwell in 1910, J. Clemens and R.E. Holttum in 1931 (Jenkins, 1978) and more recently J.H. Beaman in 1983–1984 (Price, 1987), who collected at various localities along the Crocker Range which extends from Northeastern Sarawak to Northern Sabah including Mt. Kinabalu. Meanwhile, the southern portion of Borneo (Kalimantan Indonesia) has been extensively surveyed by a group of Japanese workers in collaboration with their Indonesian counterparts at LIPI, Bogor. Their total collection amounted to more than 15,000 numbers of vascular plants and a vast number of bryophytes and lichens (Iwatsuki *et al.*, 1980; Iwatsuki & Kato, 1980a, & b, 1981 and 1983a & b). Recently in the course of preparing a general account of the ferns of the Trus Madi and Crocker Ranges, Sabah, the authors came across a number of specimens that could not be matched with other Bornean or Malesian materials. One of the species, belonging to the genus *Adiantum*, is described in the present paper. This particular species is from a medium elevation hill dipterocarp forest on the eastern slope of Trus Madi Range, where it was collected from an extensive population on the rocky bank of a small river.

Description of the New Species

Adiantum lamrianum Aziz Bidin & Razali Jaman, *sp. nov.* Fig. 1.

Rhizoma breve, erectum, basibus stipitum aggregatis, ad apicem squamatum; squamae triangulares vel lanceolatae, ad 1 mm longae, c. 0.1 mm latae, atrobrunneae; stipes usque ad 4 cm longus, ater vel atrobrunneus, sulcatus, nitidus, glaber praeter basem sparsim squamatam; filum xylematis parum sursum curvum ubique; lamina oblonga vel lineariovata, pinnata, pinnae ad c. septem pares et pinna terminalis, petiolatae, alternatae, in amplitudine similes sed infimae curtiores et flabellatae, dispositae arcte sednon imbricatae, costa carentes, ad marginem basiscopicam rectaevel parum deorsum curvae, ad marginem acroscopicam ad distalem incisae sed non profunde, tamen lobatae, in textura herbaceae vel tenuiter herbaceae, parce hirsutae, pilis uniseriatis atrobrunneis 0.3–1.0 mm longis, praeditae, venae dersae, ad paginam

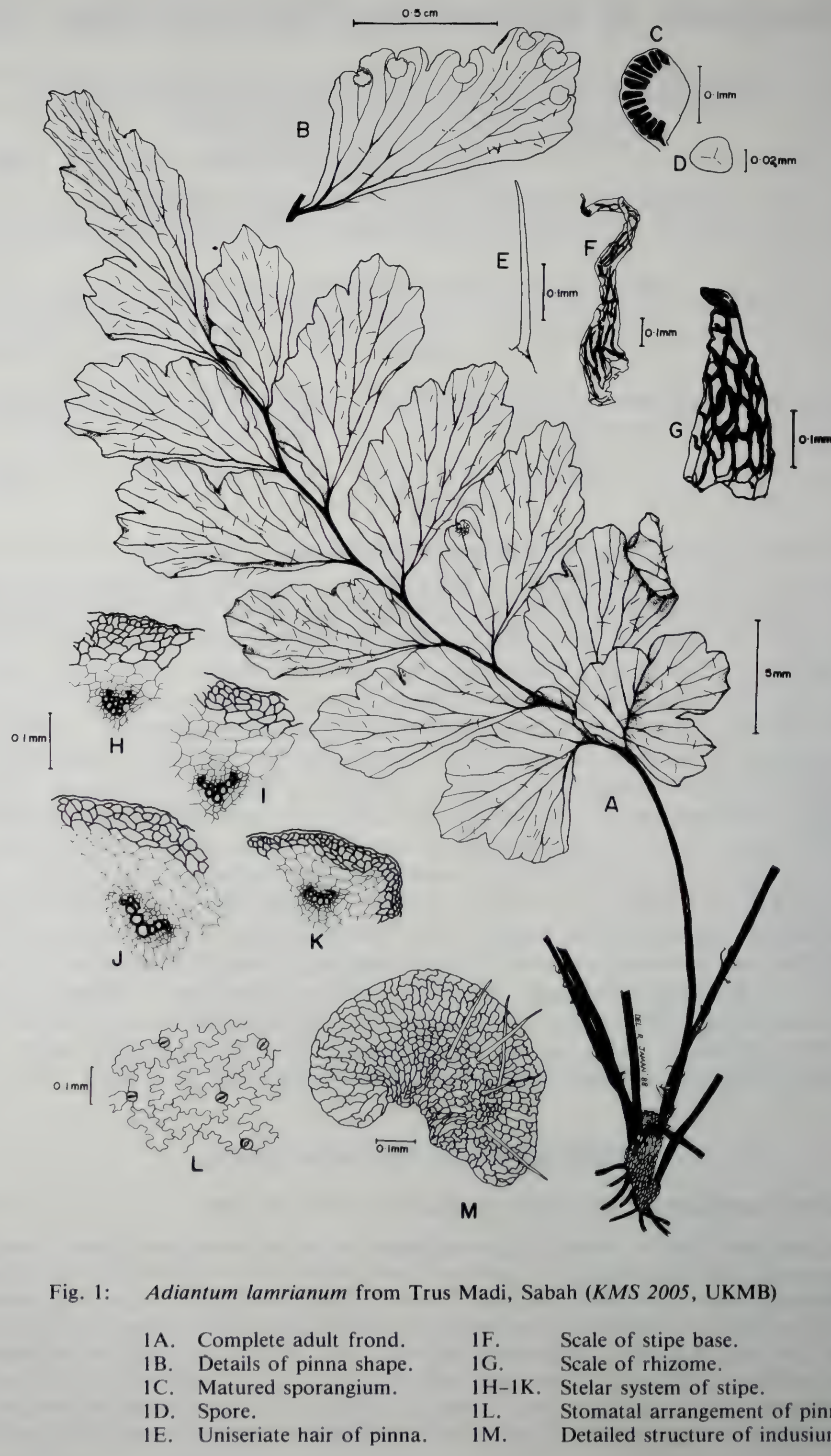

Fig. 1: *Adiantum lamrianum* from Trus Madi, Sabah (*KMS 2005*, UKMB)

1A.	Complete adult frond.	1F.	Scale of stipe base.
1B.	Details of pinna shape.	1G.	Scale of rhizome.
1C.	Matured sporangium.	1H–1K.	Stelar system of stipe.
1D.	Spore.	1L.	Stomatal arrangement of pinna.
1E.	Uniseriate hair of pinna.	1M.	Detailed structure of indusium.

superam et paginam infernam distinctae; sori usque ad sex in quoque pinna, unus in quoque sinu; indusia suborbiculares ad reniformes, usque ad 1 mm longa, 0.05 mm lata, hirsuta, pilis uniseriatis atrobrunneis c. 0.3 mm longis praedita, cellulae indusii irregularer forma, parietibus cellularum undulatis.

Rhizome short, erect, petiole-bases crowded, scaly at apex; scales triangulate to lanceolate, to 1 mm long, about 0.1 mm broad, dark-brown; stipe up to 4 cm long, blackish to dark-brown, grooved, polished, glabrous except for the sparsely scaly base, xylem strand slightly curved upward throughout; lamina oblong to linear-ovate, pinnate, to about 7 pairs with an ultimate pinna, petiolate, alternate, all about the same size except for the lowest shorter and flabellate, closely spaced but not imbricate, without costa, basiscopic margins straight or slightly curved downward, acroscopic and distal margins incised but not very deep, yet forming lobes, herbaceous or thinner, sparsely hairy with uniseriate dark-brown hairs about 0.3–1.0 mm long, veins dense, distinct on upper and lower surface; sori to six for each pinna, one for each sinus; indusia suborbicular to reniform, up to 1 mm long, 0.05 mm broad, hairy with uniseriate dark-brown hairs, hairs about 0.3 mm long, ground cells of irregular shape with undulating cell walls (Fig. 1).

Sabah. Trus Madi Range eastern slope, Kaintanu Besar River, on steep rocky slope of riverine forest of hill dipterocarp, dominated by *Shorea laevis* and *Shorea monticola*, 12 Nov. 1987, *K. Mat Salleh & Zainiruddin H. Harith, KMS 2005* (Holotype UKMB, isotypes UKMS, SING.).

This species is named in honour of Mr. Lamri bin Ali, Director of Park, Sabah in recognition of his continuous support and cooperation in helping to organize a number of field surveys in Sabah especially in the Trus Madi and Crocker Ranges.

Observations

This species has so far not been found elsewhere on both Trus Madi and Crocker Ranges. Based on his studies on the indusial character of more than 70 species of *Adiantum* worldwide, the senior author has utilised hairy versus glabrate indusium as the first segregating factor for the genus (Bidin, 1980).

Of the eight species of *Adiantum* with hairy indusia, only three species from the Malayan-Bornean region belong to the group, namely *A. diaphanum, A. hispidulum* and *A. caudatum*. The new species shows a similar habit where the outer surface of the indusium is hairy with uniseriate or single-celled hairs (Fig. 1M), similar to those found on both surfaces of the pinna. The indusium is composed of uniform ground cells of irregular shape with undulating cell walls (Fig. 1M), resembling the pattern found in *A. hispidulum* (Bidin, 1980).

The stelar system in the stipe of *Adiantum* consists of one or two traces which are usually arranged in an adaxially curved arc and shows a wide range of variations. Based on observation of the xylem configurations of the stipe in 46 species of *Adiantum* from different geographical areas, Bidin (1985) subdivided the genus into 8 groups. Sections made at three different places of the stipe (base, middle and upper) revealed that the new species belongs to the "slightly curved-upward" group to which *A. diaphanum* also belongs (Fig. 1H–1K).

Acknowledgements

We would like to thank En. Lamri bin Ali, the Director of Sabah Park for much help during our several visits to Sabah. We are grateful also to Dr. Ghazali bin Ismail and En. Rahim bin Sidek of the Universiti Kebangsaan Malaysia Sabah Campus and

Sabah Park Headquarters at Kota Kinabalu respectively for their continuous support and interest in the field. To Dr. B. Parris of the Herbarium, Royal Botanic Gardens, Kew we owe a special debt of gratitude for her help with the Latin description, and for comments on the manuscript.

References

Bidin, A. (1980). Studies in the Fern Genus *Adiantum* L. Ph.D. Thesis, University of Newcastle upon Tyne, United Kingdom (unpublished).

Bidin, A. (1985). Comparative Anatomy of the Stipe of the Fern Genus *Adiantum* L. (Adiantaceae). *Gard. Bull.* 38(2): 227–233.

Cockburn, P.F. (1978). The Flora. *Sabah Society Monograph 1978*. The Sabah Society, Kota Kinabalu, Sabah, Malaysia.

Jenkins, D.V. (1978). The First 100 Years. *Sabah Society Monograph 1978*. The Sabah Society, Kota Kinabalu, Sabah, Malaysia.

Price, M.G. (1987). Sabah Ferns Collected by John Beaman. *Contr. Univ. Mich. Herb.* 16: 189–200.

Iwatsuki, K.; J.P., Mogea; G. Murata and K. Kartawinata, (1980). A Botanical Survey in Kalimantan during 1978–1979. *Acta Phytotax. Geobot.* 31(1–3): 1–23.

Iwatsuki, K. & M. Kato. (1980a). Enumeration of Kalimantan Pteridophytes Collected during 1978–1979 (1). *Acta Phytotax. Geobot.* 31(1–3): 24–43.

_____. (1980b). Enumeration of Kalimantan Pteridophytes Collected during 1978–1979 (2). *Acta Phytotax. Geobot.* 31(4–6): 164–181.

_____. (1981). Enumeration of Kalimantan Pteridophytes Collected during 1978–1979 (3). *Acta Phytotax. Geobot.* 32(1–4): 121–132.

_____. (1983a). Additions to the Enumeration of East Kalimantan Pteridophytes 1. *Acta Phytotax. Geobot.* 34(1–3): 55–65.

_____. (1983b). Additions to the Enumeration of East Kalimantan Pteridophytes 2. *Acta Phytotax. Geobot.* 34(4–6): 130–141.

Four New Taxa of Philippine Rattans (Palmae: Calamoideae)

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Abstract

Calamus aidae E. Fern., *C. balerensis* E. Fern., *C. ornatus* Blume var. *pulverulentus* E. Fern. and *Daemonorops polita* E. Fern. are described as new taxa of rattans from the Philippines.

Recent intensive collection of herbarium material of rattans in the Philippines has resulted in the discovery of undescribed taxa. There is need to provide names for these rattans as most of them are already being commercially exploited and their habitats are threatened. This paper is published to validate names for four new taxa.

Calamus aidae E. Fern., *sp. nov.* Fig. 1

Species distinctissima, inter species Philippinenses flagello cirroque carentibus, foliolis infra dense albide-farinosis setosisque, ocrea papyracea mox fatiscenti distinguibilis. *Typus:* Samar, Basey, Guirang, Rawis, *Baja-Lapis 123* (holotypus K; isotypus LBC).

Robust, solitary, pleonanthic, dioecious rattan. Stems climbing to 15 m; stem without sheaths 2.5–4.0 cm dia., with sheaths to 6 cm dia.; internodes to 18 cm long. Leafsheaths densely covered with creamish-green, mealy indumentum and armed with brown, slender, narrowly laminar and acicular spines to 6.5 cm long, arranged closely in partial whorls, those around leafsheath mouth longer, erect; the spines very brittle and readily breaking off; knee present although hardly developed, armed as the sheath but less densely so; ocrea to 40 cm long, 3 cm wide near the base, papery, creamish or dirty white in colour, the proximal portion sparsely covered with brownish indumentum and armed along the edges with acicular spines to 6 cm long, ocrea prominent in newly expanded leaves, but quickly tattering and disintegrating. Leaf sub-cirrate, to 3 m long, including petiole; cirrus none; petiole to 30 cm long, semi-circular in transverse section, flattened to slightly concave on adaxial side, convex on abaxial side, to 3.5 cm wide, 1.5 cm thick near base, armed with scattered, slender, laminar spines to 5 cm long on adaxial surface and along edges, the spines decreasing in size distally, abaxial surface generally smooth, except near the edges; petiole and rachis covered with brownish, mealy indumentum; rachis at mid-portion nearly triangular in section, bifacial above and armed along top edge with short rigid spines to 4 mm long, arranged 15–25 mm apart, flattened or convex below and armed with rigid and robust 3-hooked grapnel spines to 1.5 cm long, arranged 6–8 cm apart, becoming 2-hooked then single-hooked grapnel spines towards tip. Leaflets to 130 on each side of the rachis, coriaceous, stiff, regularly arranged to 3 cm apart, linear-lanceolate; adaxial surface drying pale or light greenish-yellow, glabrous, except for very short bristles to 2 mm long and spaced to 7 mm apart along margins, transverse veinlets prominent; abaxial surface covered with chalky-white indumentum and dense bristles along all costae, those along the mid-costa to 4 mm long, all others generally shorter;

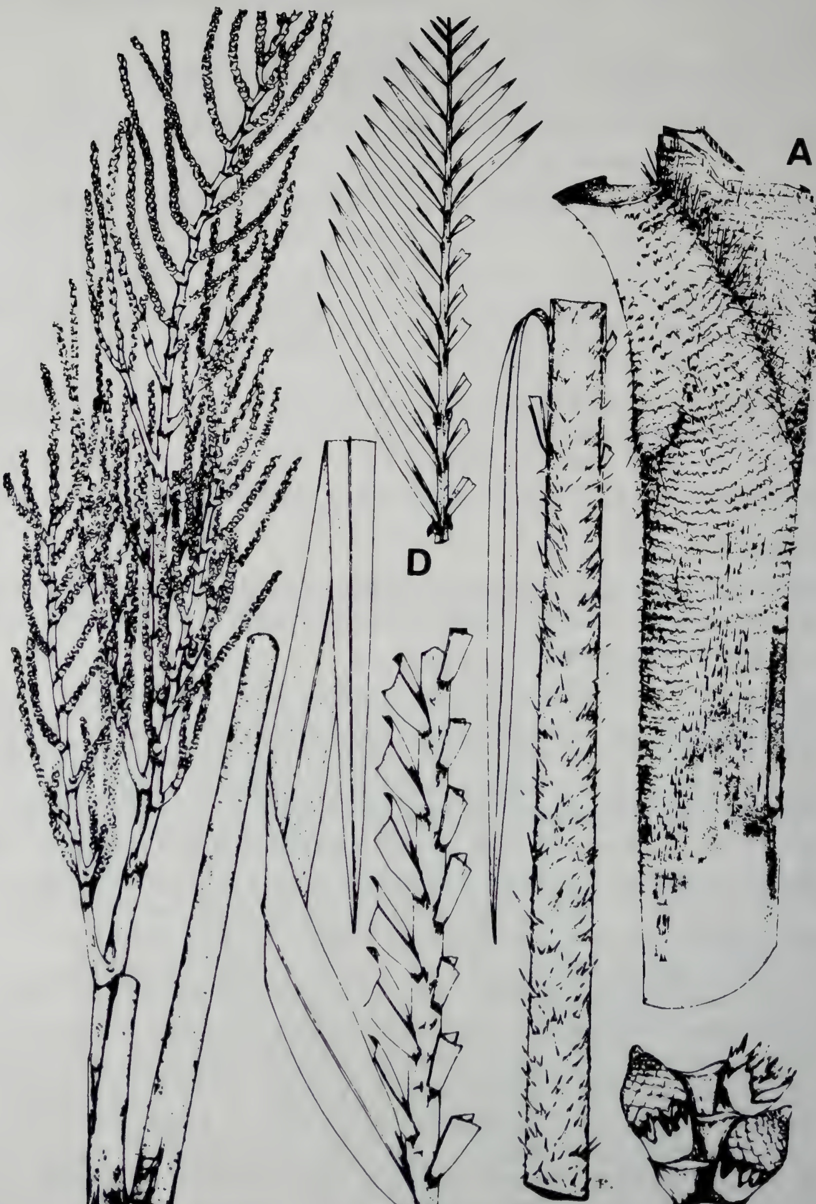

Fig. 1. *Calamus aidae* E. Fern. — A. leafsheath, ×2/5; B. petiole, ×2/5; C. mid-portion of leaf, ×2/5; D. leaf apex, ×2/5; E. portion of pistillate inflorescence, ×2/5; F. portion of rachilla with young fruits, ×2 1/2. A, E, F from *Baja-Lapis 123; B, C, D* from *Fernando 414.*

basal leaflets to 25 × 1.0 cm; mid-lamina leaflets to 49 × 2.2 cm, apical leaflets to 5.5 × 0.3 cm, smaller, rudimentary leaflets often present. Staminate inflorescence not known. Pistillate inflorescence generally ascending, to 2 m long, with up to 5 partial inflorescences spaced to 50 cm apart, decreasing in size distally; prophyll tubular, to 20 × 1.8 cm, elliptic in section, 2-keeled, armed with scattered laminar bulbous-based spines to 1.5 cm long, mouth of prophyll surrounded with bristles to 5 cm long; other bracts similar but decreasing in size distally and becoming less densely armed to glabrous; peduncle c. 12 × 1 cm to the prophyll scar; partial inflorescence to 35 cm long, bearing to 20 tubular bracts, each to 13 × 8 mm, the upper half often tattering, unarmed and covered with creamish-green indumentum, the proximal up to 7th bract bearing second-order branches, the succeeding and ultimate bracts bearing rachillae; second-order branches to 19 cm long, with up to 11 rachillae, each to 40–90 × 3 mm, generally erect, borne above subtending bract; rachilla bearing distichously arranged bracts, each subtending a flower pair, alveolus of sterile staminate flower c. 1 mm dia., that of pistillate flower c. 1.5 mm dia. Sterile staminate and pistillate flowers not known. Fruit (immature) globose, c. 7 × 6 mm, beaked; pericarp with scales arranged to 13 vertical rows, pale yellowish-green and with prominent mid-scale groove. Seed not known. Seedling leaf (eophyll) pinnate, with 5–7 pairs of leaflets, each to 35 × 2 mm, with chalky white indumentum and short bristles along margins and midcosta on undersurface.

Distribution and Habitat: Luzon (Sorsogon Prov.), Samar, Biliran, Dinagat, and Mindanao (Surigao Prov. and Agusan del Sur Prov.); in dipterocarp forest at c. 50–500 m alt. Endemic.

Vernacular names: Ulisi (Biliran), Ulasi (Samar), Inhian (Agusan del Sur).

Specimens examined: Luzon: Sorsogon Prov., Irosin, Mt Bulusan, *Elmer 16871* (BM, K); Samar: Basey, Guirang, Rawis, *Baja-Lapis 123* (holotype K; isotype LBC); Biliran: Naval, Mohon, *Fernando 679* (LBC); Dinagat: locality not known, *Ramos & Pascasio B.S. 35250* (in part, as to portion of inflorescence only) (K); Mindanao: Surigao Prov., locality not known, *Ponce F.B. 25070* (BM, K); Surigao del Sur Prov., Bislig, *Fernando 727* (LBC), Agusan del Sur Prov., Trento, *Fernando 414* (K, LBC).

Calamus aidae is an unusual and very distinctive Philippine rattan in the curious absence of either a cirrus or a flagellum, in the dense short bristles and chalky-white indumentum on the undersurface of leaflets, and in the long, papery ocrea which quickly disintegrates. Earlier collections of this species have been referred to either *C. discolor* Mart. or *C. bicolor* Becc. owing to its similarly discolorous leaflets, *C. discolor*, however, has distinctly ecirrate leaves and the leafsheath bears a flagellum; *C. bicolor*, on the other hand, has leaves with a prominent cirrus. Features of the inflorescence suggest that *C. aidae* may be related to *C. inops* Becc. ex Heyne of Sulawesi (Dransfield, pers. comm.).

This species is named for Mrs Aida Baja Lapis who collected the type specimen.

Calamus balerensis E. Fern., *sp. nov.* Fig. 2

C. usitato Blco. affinis sed foliis subsessilibus multo brevioribus, foliolis non nisi marginibus setosis, pagina adaxiali in sicco nitida, semine brunneo laeve differt. *Typus:* Luzon, Aurora Prov., Baler, *Fernando 478* (holotypus LBC; isotypus K).

Very slender, clustering, pleonanthic, dioecious rattan. Stems to 3 m long, without sheaths 3–4 mm dia., with sheaths to 6 mm dia., internodes to 8 cm long. Leafsheaths

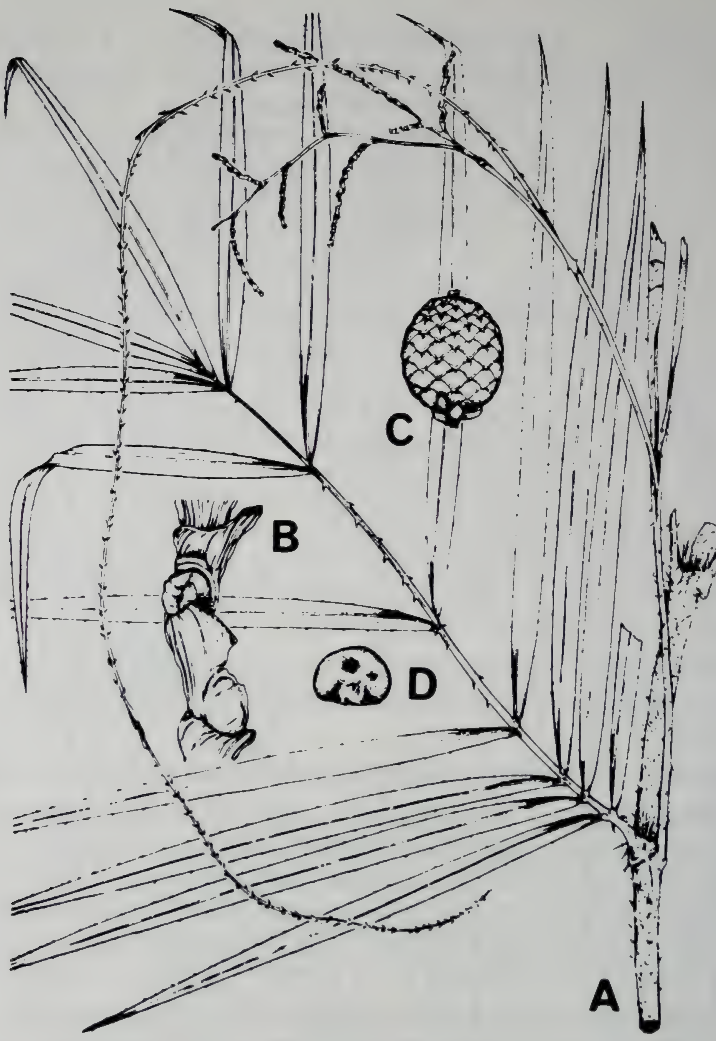

Fig. 2. *Calamus balerensis* E. Fern. — A. sheathed stem with one leaf and old infructescence, ×1/2; B. detail of rachilla, ×6; C. fruit, ×1 1/4; D. seed, ×1 1/4. All from *Fernando 478.*

bright green, armed with scattered, light-brown, slender, acicular spines to 7 mm, yellowish and broad at their base, those around leafsheath mouth longer to 18 mm, erect; knee conspicuous, armed as the sheath; flagellum to 50 cm long, armed with short rigid spines; ocrea inconspicuous. Leaf ecirrate, c. 14–18 cm long; petiole very short, to 5 mm, sometimes nil; rachis angular in section, bifacial above, flattened below and armed with solitary black-tipped, reflexed, rigid spines to 3 mm long. Leaflets up to 8 on each side of the rachis, pendulous, irregularly arranged 2–45 mm apart, singly or in groups of up to 4 and held in same plane, linear-lanceolate, adaxial surface drying glossy greyish-green, the costae on both surfaces unarmed, except for very short bristles along the margin, becoming more conspicuous near the leaflet tip, the bristles to 1 mm or often less; transverse veinlets prominent; basal leaflets to 16.8 × 0.7 cm, mid-lamina leaflets to 18.4 × 0.8 cm; apical leaflets to 1.2 ×

0.7 cm, the last pair joined to 6 mm along rachis tip. Staminate inflorescence not known. Pistillate inflorescence pendulous, to 60 cm long, with up to 3 partial inflorescences and terminating in a well-defined flagellum, the partial inflorescences spaced to 15 cm apart, decreasing in size distally; prophyll tubular, to 17 × 0.3 cm, armed with scattered short, black, rigid spines to 2 mm; other bracts similar but decreasing in size distally; peduncle c. 16 × 0.2 cm to the prophyll scar; partial inflorescence pendulous, to 12 cm long, with up to 6 second-order branches of which the proximate one often bearing up to 3 rachillae, succeeding and ultimate second-order branches as rachillae; rachilla to 25–35 × 2 mm, very slender, flexuous, bearing distichously arranged, striate bracts, each subtending a flower pair, alveolus of sterile staminate flower c. 0.5 mm dia., that of pistillate flower c. 1 mm dia. Sterile staminate and pistillate flowers not known. Fruit globose-oblong, to 1.5 × 1 cm when fresh, with a rather obtuse or blunt beak; pericarp with scales arranged in 15 vertical rows, dull light-green to creamish-yellow, with light brown margins and mid-scale groove. Seed plano-convex, to 1 × 1.2 × 0.8 cm when fresh, smooth, brown and glossy on surface; endosperm homogenous. Seedling leaf not known.

Distribution and Habitat: Luzon (Aurora Prov.); in forest with large boulders, facing the sea, c. 50 m alt. Endemic.

Specimens Examined: Luzon: Aurora Prov., Baler, Digisit, *Fernando 478* (holotype LBC; isotype K), Semento, *Hernaez 3874* (CAHP).

This species belongs to Section *Coleospathus* Furt. and is closely related to *C. usitatus* Blco. differing in the much shorter leaves with a very short and often absent petiole, in the leaflets armed with short bristles only along the margins and drying glossy on the adaxial surface, and in the seed which is brown and generally smooth on the surface. In contrast, *C. usitatus* generally has longer leaves with a distinct, well-developed petiole; the leaflets are armed with bristles on both surfaces and along margins, and drying dull on the adaxial surface; the seed is black and with rough, irregular surface. Furthermore, *C. usitatus* often has leafsheaths and petioles covered with dull greyish-brown indumentum, a feature not found in *C. balerensis.* Although *C. usitatus* is such a variable species, *C. balerensis* has characters which amply separate it as a distinct species.

The specific epithet refers to the type locality.

Calamus ornatus Blume var. **pulverulentus** E. Fern., *var. nov.* Fig. 3

A ceteris varietatibus vaginis foliorum semper inermibus et simul petiolis, rachidibus foliorum et bracteis inflorescentiae indumento cineraceo-brunneo dense tectis, et squamis fructu atratis differt. *Typus:* Mindanao, Zamboanga Peninsula, La Paz, *Fernando 599* (holotypus LBC; isotypus K).

Robust, clustering, pleonanthic, dioecious rattan. Stems climbing to 20 m, stem without sheaths to 2.5 cm dia., with sheaths to 5 cm dia.; internodes to 38 cm long. Leafsheaths completely inerm, densely covered with greyish-brown, mealy or powdery indumentum; knee very conspicuous, unarmed as the leafsheath; ocrea scarcely developed; flagellum to 5 m long, armed with rigid grapnel spines. Leaf subcirrate, rarely ecirrate, to 3 m long; petiole to 30 cm long, semi-circular in transverse section, flattened to slightly convex on adaxial side, convex on abaxial side, to 2.5 cm wide, 1.0 cm thick near base, armed with solitary rigid spines to 6 mm, only along edges and occasionally along mid-portion on abaxial surface; petiole and rachis covered with greyish-brown, mealy indumentum, rather thick below and along the edges; rachis at mid-portion triangular in section, bifacial and unarmed above, flattened or slightly convex below and armed with black, rigid, grapnel spines arranged to 4–8 cm apart.

Fig. 3. *Calamus ornatus* Blume var. *pulverulentus* E. Fern. — A. leafsheath with base of flagellum, ×2/5; B. petiole, ×2/5; C. mid-portion of leaf, ×2/5; D. leaf apex, ×2/5; E. partial pistillate inflorescence, ×2/5; F. sterile staminate flower, ×3 1/3; G. pistillate flower in bud, ×3; H. vertical section of pistillate flower in bud, ×3; I. immature fruit, 3/5. All from *Fernando 599*.

Leaflets to 25 on each side of the rachis, arcuate, regularly arranged to 9–14 cm apart, broadly linear-elliptic to lanceolate, generally unarmed on both surfaces except near leaflet tip where midcosta on adaxial side and margins are armed with short spiculae to 1.5 mm, transverse veinlets prominent; basal leaflets to 57 × 6 cm; mid-lamina leaflets to 70 × 7 cm; apical leaflets to 15 × 1.5 cm, the terminal pair often fused to the tip of rachis. Staminate inflorescence not known. Pistillate inflorescence flagelliform, pendulous, to 3 m long, with up to 3 partial inflorescences and terminating in a well-defined flagellum, the partial inflorescences spaced to 55 cm apart, slightly decreasing in size distally; peduncle to 8 × 3 cm to the prophyll scar, laterally compressed and 2-keeled, unarmed, covered with greyish-brown, mealy indumentum; prophyll closely tubular to 56 × 3 cm, covered with greyish-brown, mealy indumentum and generally unarmed except along edges on proximal side where sparsely armed with bulbous-based laminar spines to 1.5 cm long; other primary bracts similar but decreasing in size distally and completely unarmed, all other bracts similarly covered with mealy indumentum and margins fringed with caducous cream-coloured hairs to 3 mm; partial inflorescences to 42 cm long, arcuate, bearing to 21 reflexed rachillae, each rachilla subtended by a tubular bract to 3.5 × 1.5 cm, decreasing in size distally; rachilla c. 9–20 × 1 cm, robust, decreasing in length distally, and bearing to 20 bracts, each subtending a flower pair, alveolus of sterile staminate flower c. 2 mm dia., that of pistillate flower c. 4 mm dia. Sterile staminate flower c. 6 × 3 mm; calyx 3-lobed, with basal tube to 4 mm and triangular lobes to 1.5 mm; corolla with very short basal tube and 3 petals to 4 × 2 mm; stamens 6, with filaments to 2 mm long and anthers 1.5 × 0.5 mm; pistillode trifid to 1 mm high. Pistillate flower c. 7 × 5 mm; calyx tubular in basal 4 mm with three triangular lobes to 3 × 2 mm; corolla with short basal tube and three petals to 5 × 2.5 mm; staminodal ring to 2.5 mm high bearing 6 minute triangular teeth; ovary c. 4 × 1.5 mm. Fruit (immature) obovoid-ellipsoid or spindle-shaped, c. 4.2 × 2 cm, tipped with a beak to 4 mm; pericarp with scales arranged in 15 vertical rows, dark brownish-black with darker margins and prominent mid-scale groove. Seed from immature fruit rather angular; sarcotesta sour; endosperm homogenous. Seedling leaf not known.

Distribution and Habitat: Palawan and Mindanao (Zamboanga Peninsula); in dipterocarp forest at c. 100–800 m alt. Endemic.

Vernacular names: Borongan (Zamboanga), Mananga (Palawan).

Specimens Examined: Palawan: Puerto Princesa, Bagumbayan, *Dransfield 5486* (K, LBC), Irawan, *Madulid 1007* (K, PNH); Aborlan, Talakigan River, *Hernaez 3875* (CAHP, LBC); Mindanao: Zamboanga Peninsula, Malayal, *Fernando 589* (K, LBC), La Paz, *Fernando 599* (holotype LBC; isotype K).

This new variety is distinguishable from all other varieties of *C. ornatus* Blume in the leafsheaths which are consistently completely unarmed and densely covered with greyish-brown, powdery indumentum, including petioles, leaf rachis, and inflorescence bracts, and in the dark brownish-black fruit scales. The other endemic variety of *C. ornatus* in the Philippines, *C. ornatus* Blume var. *philippinensis* Becc., is more widespread in the islands and differs from *C. ornatus* var. *pulverulentus* in the leafsheaths being dark green and armed with laminar spines and in the fruit scales which are yellowish with blackish margins.

The varietal epithet refers to the powdery indumentum on the leafsheaths.

Daemonorops polita E. Fern., *sp. nov.* Fig. 4

Structura inflorescentiae et bracteis secondariis tertiariisque saepe findentibus *D. ruptili* Becc. var. *ruptili* affinis sed habitu solitario, vagina folii spinis complanatis latioribus basi tumidis in verticillis partialibus dispositis, geniculo conspicuo, foliolis confertioribus, subtus 3-nervis setosis, fructu rotundiore differt; *D. ruptili* Becc. var. *acaulescenti* Dransf. idemque affinis sed habitu et folio differt. *Typus:* Mindanao, Zamboanga Peninsula, La Paz, *Fernando 575* (holotypus LBC; isotypi BH, K).

Robust, clustering, pleonanthic, dioecious rattan. Stems climbing to 15 m, stem without sheaths to 2.5 cm dia., with sheaths to 4 cm dia., internodes to 22 cm long. Leafsheaths covered with reddish-brown indumentum and armed with pale yellowish, laminar spines to 4 cm long, to 1 cm broad at base, rigid, arranged in partial whorls, generally horizontal or reflexed; knee conspicuous, only sparsely armed with shorter laminar spines, or generally smooth; ocrea inconspicuous. Leaf cirrate to 3 m long including cirrus to 1 m long; cirrus armed with grapnel spines; petiole yellowish in colour, to 20 cm long, semi-circular in section, slightly concave on adaxial side especially near base, convex on abaxial side, to 2.5 cm wide, 1 cm thick near base, armed with laminar spines to 3 cm long, arranged in groups along the edges and abaxial surface and with shorter spines to 1.5 cm long on adaxial surface, all spines on petiole decreasing in size distally; abaxial surfaces of petiole and rachis yellowish, covered with indumentum as the leafsheath; rachis at mid-portion nearly triangular in section, bifacial above, smooth or only sparsely armed with short spines, flattened or convex below and armed with rigid grapnel spines to 8 cm apart. Leaflets to 85 on each side of the rachis, coriaceous, stiff, regularly arranged, rather closely set to 1.7–2.0 cm apart, linear-lanceolate, bright green, concolorous; adaxial surface glabrous to sparsely bristly along mid- and side costae, especially toward leaflet tip, the margins armed with short bristles to 1 mm, often in pairs, transverse veinlets rather indistinct; abaxial surface armed with bristles to 2 mm long, very closely set along mid-costa and sparsely set to 3–20 mm apart along two side costae; basal leaflets to 15 × 0.8 cm; mid-lamina leaflets to 32 × 2.7 cm, the tips often with a brittle mucro to 1.5 cm long; apical leaflets to 25 × 1.0 cm, smaller, rudimentary leaflets occasionally present. Staminate inflorescence erect, to 70 cm long, with up to 14 partial inflorescences spaced to 4–8 cm apart, decreasing in size distally; peduncle c. 10 × 1.3 cm to the prophyll scar, flattened and 2-keeled, covered with reddish-brown indumentum and armed with rigid laminar spines to 1.5 cm long; prophyll c. 32 × 2 cm, ± woody-textured, but brittle when dry, very densely covered with reddish-brown indumentum, only sparsely armed with short spines to 8 mm and mainly along edges, splitting down middle portion; other primary bracts decreasing in size distally, ± armed as the prophyll but even more sparsely so, covered with indumentum as the prophyll; prophyll and other primary bracts subtending a partial inflorescence, all caducous at anthesis; basal partial inflorescence to 10 cm long with up to 12 crowded rachillae, each 2.5–3.0 cm long × 0.6 cm wide, subtended by a persistent bract with a distinct triangular limb to 1.5 cm long, often tattering, each rachilla bearing up to 15 distichously arranged bracts, each subtending a flower, alveolus of flower to 3 mm dia., apical partial inflorescence simple, unbranched. Staminate flower to 6 × 3 mm, cylindrical in bud; calyx greenish, 3-lobed, with basal tube to 3 mm, and triangular lobes to 1.5 mm; corolla yellowish-brown, with short basal tube and 3 petals to 5 × 2.5–3.0 mm; stamens 6 with free filaments, white, to 6 mm long at anthesis, anthers yellow to 3 × 1 mm; pistillode to 2 mm long, trifid. Pistillate inflorescence as the staminate but more robust, peduncle slightly longer, and prophyll does not subtend a partial inflorescence; whole inflorescence arching when in fruit; rachilla c. 4 × 0.8 cm, covered with reddish-brown indumentum, rachilla bracts with a prominent triangular limb to 6 mm; alveolus of sterile staminate flower c. 2 mm

Fig. 4. *Daemonorops polita* E. Fern. — A. sheathed stem, ×2/5; B. petiole, ×2/5; C. mid-portion of leaf, ×2/5; D. leaf apex with cirrus, ×2/5; E. portion of infructescence, ×2/5; F. sterile staminate flower, ×3; G. pistillate flower, ×3; H. immature fruit, ×1 1/4. All from *Fernando 575*.

dia., that of pistillate flower c. 5 mm dia. Sterile staminate flower as the fertile but with undeveloped anthers. Pistillate flower c. 8 × 4 mm; calyx tubular in basal 4 mm with three triangular lobes to 2 × 2.5 mm; corolla with basal tube to 2 mm and three petals to 4 × 3 mm; staminodal ring bearing 6 teeth to 2 mm long; ovary c. 3 × 2.5 mm with three reflexed stigmas to 2 mm long. Fruit (immature) globose, c. 1.3 × 1.4 cm, tipped with a beak to 5 mm; pericarp with 15 vertical rows of glossy, yellowish scales with prominent reddish-brown margins and mid-scale groove. Seed globose, c. 1 × 1 cm; endosperm ruminate; embryo basal. Seedling leaf (eophyll) pinnate with 6 pairs of leaflets, each c. 40 × 4 mm.

Distribution and Habitat: Mindanao (Zamboanga Peninsula); in dipterocarp forest at c. 600–800 m alt. Endemic.

Vernacular name: Lapa-utong.

Specimens Examined: Mindanao: Zamboanga Peninsula, La Paz, *Fernando 575* (holotype LBC; isotypes BH, K), *Fernando 719* (BH, K, LBC), Kabasalan, Dipala Mt, *Ebalo 771* (BH).

This new species clearly belongs to Section *Piptospatha* and is most closely similar to *D. ruptilis* Becc. var. *ruptilis* of Borneo in the inflorescence structure and in the persistent, often splitting secondary and tertiary bracts. It is, however, distinguished by its generally solitary habit, in the leafsheath armed with broader-based laminar spines arranged in partial whorls, in the more conspicuous knee, in the more closely set regular arrangement of the leaflets, in the leaflets bristly on three nerves on the undersurface, and in the more rounded fruit. *D. polita* is also similar to *D. ruptilis* Becc. var. *acaulescens* Dransf. in the inflorescence structure and in the shape and glossiness of the fruit but the habit is quite different.

The specific epithet refers to the polished, glossy scales of the fruit.

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Tree Distribution Patterns in the Bukit Timah Nature Reserve, Singapore.

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Abstract

All living stems > = 2 cm dbh were marked, identified and mapped at a scale of 1 cm to 1 m in two 0.24-ha plots in the Bukit Timah Nature Reserve, Republic of Singapore. The Fern Valley plot was V-shaped in cross-section and contained a small area of exposed bedrock and several boulders along an ephemeral stream channel; the Jungle Fall Valley plot had no stream channel and neither exposed bedrock nor boulders. In both plots combined (0.48 ha), there were over 290 species representing 53 families. The two plots shared 95 species, while 76 were unique to the Fern Valley plot and 119 to the Jungle Fall Valley plot. Fern Valley had 20% fewer species, 44% fewer stems, 23% less total basal area and 40% fewer woody climbers > = 1.4 m tall than Jungle Fall Valley. Shallower depth to granitic bedrock in Fern Valley is hypothesized to be a contributing factor for this difference. In both plots, the Dipterocarpaceae had the greatest basal area and the Euphorbiaceae the greatest density and number of species. The distributions of *Shorea curtisii* and *Pimelodendron griffithianum* along slopes in these small plots conformed to their observed ecological preferences on a larger scale in the Malay Peninsula. The presence of a few old trees of pioneer species with little regeneration indicated an on-going process of recovery from disturbance during and prior to World War II.

Introduction

The purposes of this study were to compare the vegetation of two plots in the Bukit Timah Forest Reserve, Singapore, and to analyze the distribution patterns of woody species along elevational gradients. Because the two plots were only 250 m apart and presumably shared a similar vegetational history, I set out to discover how similar they would be in species composition, stem density, total basal area and size distributions of the stems of those species represented by more than five stems or contributing more than 0.5% of each plot's basal area. Answers to these questions should provide a better understanding of the natural variability of the vegetation within the reserve and a basis for prediction of future changes in species composition.

The Bukit Timah Nature Reserve was established in 1883 and covers an area of 71 ha but lacked governmental protection between 1930 and 1937 and during World War II (Corlett 1988). The highest point on Singapore Island is located within the reserve and has an elevation of 162.5 m. Bedrock is granite probably of post-lower Jurassic age (Wong 1969, Hill 1973, Nature Reserves Board 1975). Ives (1977) described the soils of Bukit Timah as belonging to the Rengam series, which is well-drained and characterised by a dark, greyish-brown topsoil 10–20 cm deep; there is a yellowish brown subsoil, which grades to a yellowish-red, firm horizon below 1.5 m.

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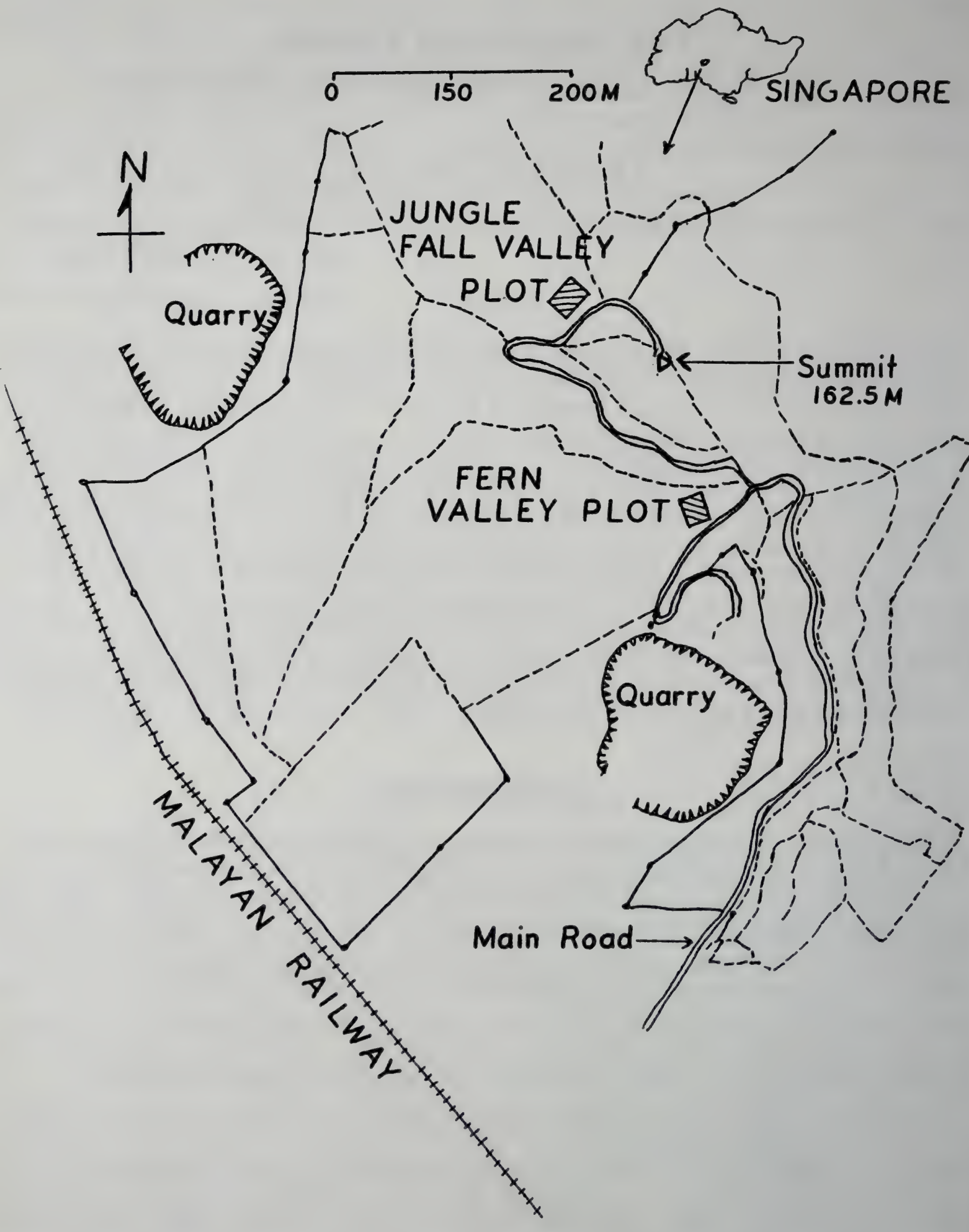

Fig. 1: Map of the Bukit Timah Forest Reserve showing the locations of the two 0.24 ha plots.

The flora of the reserve has been intensively studied and is the source of type specimens of many species. Hill (1977) constructed a vegetation map of Singapore and reported the presence of 99 tree species at the Bukit Timah Forest Reserve. Wong (1987) sampled 687 trees > = 24 inches in girth in the reserve. He reported tree densities of 57 to 137 stems per acre and postulated that past harvesting of smaller stems by residents of nearby villages could account for areas of low tree density. His total sample of 849 trees represented 212 species, 111 genera and 44 families. Whitmore (1984) concluded that the vegetation of the Bukit Timah Forest Reserve was an isolated relict of dipterocarp forest with fewer species that would normally be present in typical lowland tropical moist forest on the nearby Malay Peninsula. He also described the lowland dipterocarp forests on ridges of the Malay Peninsula as being dominated by *Shorea curtisii*, which forms an edaphic climax there as it does at Bukit Timah.

The following animals were observed during sampling: Long-tailed Macaque (*Macaca fasicularis*), Flying Lemur (*Cynocephalus variegatus*), Red-bellied Squirrel (*Callosciurus notatus*), and Great Racquet-Tailed Drongo (*Dicrurus paradiseus*).

Materials and Methods

Design and Layout

I selected one 0.24 ha plot in Fern Valley (Fig. 1) and one about 250 m away in Jungle Fall Valley on the bases of minimal slope, lack of excessive disturbance from tree falls, width of more than 60 m across each valley, and absence of roads and foot paths. Each plot was 60 by 40 m and was oriented so that the long axis was perpendicular to the path of water drainage. Fern Valley drains to the west and Jungle Fall Valley to the north-northeast. The vegetation of each plot was sampled by use of six contiguous quadrats (in two rows of three quadrats) 20 m square (400 m^2). In Fern Valley, two of these quadrats were on the north side of the valley and had slopes of 25° towards the southwest (220°). The valley bottom was on the southern edge of these quadrats. Four quadrats were on the south side of the valley and had slopes of 18° or less towards the northwest (320°). In Jungle Fall Valley, all six quadrats had slopes of 12° to 28° to the north.

Stem Measurement, Labeling and Identification

In each plot, the diameters at 1.4 m height (dbh) of all living stems > = 2 cm dbh were measured, and a numbered aluminium tag was attached to each. I estimated stem heights and mapped the positions of all living and dead stems > = 2 cm dbh and fallen stems > = 20 cm in diameter at a scale of 1 cm equal to 1 m (Figs. 2 & 3). The following plant growth forms were defined in terms of a species' potential adult stem diameter as follows: a species described as a treelet or shrub had stems < = 5 cm dbh; small trees, 6–15 cm; trees, 16–30 cm; and large trees, >30 cm. Samples of leaves and fruits were collected for later identification at the Singapore Botanic Gardens Herbarium. Scientific nomenclature of plant species follows Keng (1973, 1974, 1976, 1978, 1980, 1982).

Plant specimens collected from the study plots were deposited at the Department of Botany, National University of Singapore, and their identification was verified by Dr R.T. Corlett, a faculty member in the department. A partial set of specimens is stored in the herbarium of the Department of Biology, West Liberty State College, West Liberty, West Virginia 26074, USA. Copies of my field notes and maps of the two plots are on file at the Department of Botany, National University of Singapore. Species names with authorities are listed by family in the Appendix.

Pattern Analysis

To determine whether or not species with four or more stems per plot differed from each other in distribution patterns along valley slopes, I used the map of each plot to measure the distances from each stem perpendicular to the valley bottom or drainage path (D–S) and to the point of lowest elevation (DLP). The Jungle Fall Valley plot did not have a clearly defined valley bottom while the Fern Valley plot did. I estimated the valley bottom in Jungle Fall Valley to be along a line from the lowest point perpendicular to the long axis of the plot. To study other aspects of distribution patterns, the distance of each stem was measured to the nearest conspecific (NNSS), to the nearest neighbour (NN), and to the nearest fallen stem (DNFT) > = 20 cm in diameter.

To perform regression and correlation analyses, the Daisy statistics software for the Apple Computer, Rainbow Computing Inc., 9718 Pagoda Blvd., Pasedena, California, USA, was used.

Results and Discussions

Differences in the Vegetation of the Two Plots

The vegetation of the Fern Valley plot was simpler in composition and structure than that of the Jungle Fall Valley plot. While the two plots shared 95 species, 76 were unique to Fern Valley and 119 to Jungle Fall Valley. The Fern Valley plot had 20% fewer species, 44% fewer stems > = 2 cm dbh, 23% less total basal area, and 40% fewer woody climbers > = 1.4 m tall (Table 1). A comparison of the species area curves for the two plots (Fig. 4) shows the curve for Jungle Fall Valley (bivariate normal correlation coefficient, r = 0.9838, cumulative number of species versus number of 10 by 10 m quadrats) to be consistently higher than that for Fern Valley (r = 0.9768) with the gap between the two widening after ten 100-m^2 quadrats (Connor and McCoy 1979). In both plots, the Dipterocarpaceae had the greatest basal area and the Euphorbiaceae the greatest density and number of species (see Appendix).

The differing characteristics of the vegetation in the two plots may be due to chance or may indicate that there are environmental differences between them. Soil depth is a possible cause of the observed differences. Physical evidence for less soil depth in Fern Valley includes exposed bedrock near the upper end of the plot's stream channel and large boulders one to two metres in largest dimension lying exposed toward the lower end of the channel (Fig. 2). About 50 m west of the Fern Valley plot, I observed several large cracks in the soil perhaps caused by soil slippage during exceptionally heavy rains. In contrast, the Jungle Fall Valley plot contained neither rock exposures nor soil cracks. About 2 m from the southeast corner of the Jungle Fall Valley plot there was a circular hole of unknown origin and age, 1.3 m in diameter and 3–4 m deep with no sign of bedrock along its sides.

Shorea curtisii (Dipterocarpaceae) had a greater basal area than any other species in each plot (Tables 2 and 3). Of the dicotyledonous tree species capable of attaining great size, it also had the most individuals in the 2–10 cm dbh size class. In Fern Valley its stems grew at the highest average elevation (#20, Fig. 5), and in Jungle Fall Valley at the ninth highest elevation (#6, Fig. 6). I assume that the elevational gradients depicted in Figs. 5 and 6 may reflect not only water relations (with the driest end being at the upper right corner) but also differences in soil depth, texture, chemical composition, and a tendency for soil slippage. Whitmore (1984) noted that *Shorea curtisii* characteristically grows along ridge crests between 225 and 750 m on inland

Fig. 2: Map of the Fern Valley plot showing the locations of all living stems >= 2 cm dbh and fallen stems >= 20 cm in diameter. The plot is 40 by 60 m as measured on the south and east sides respectively. The west side measures slightly more than 60 m.

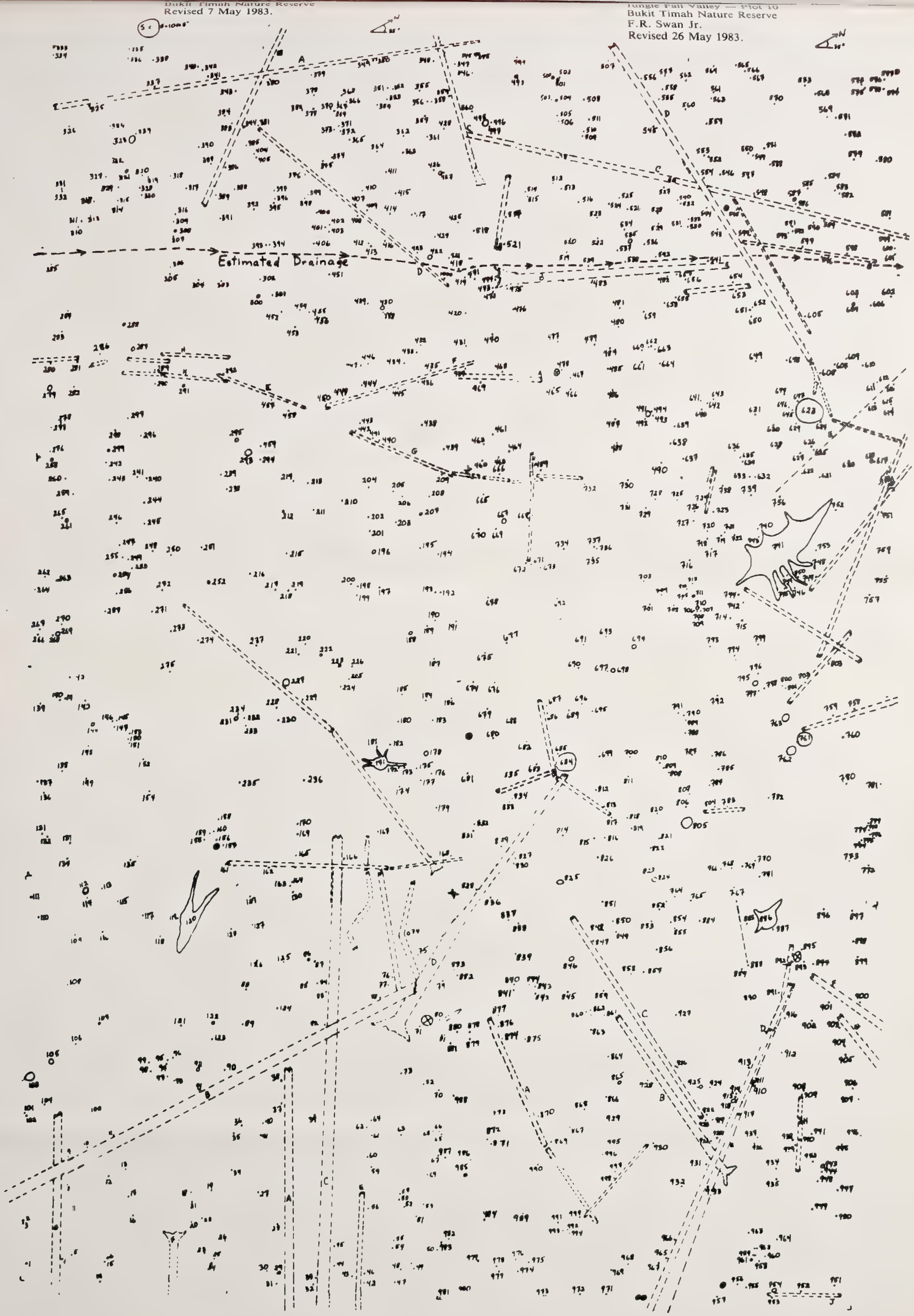

Fig. 3: Map of the Jungle Fall Valley plot showing the location of all living stems >= 2 cm dbh and fallen stems >= 20 cm in diameter. The plot is 40 by 60 m.

Table 1
A comparison of the major features of the vegetation and soils in the Fern Valley and Jungle Fall Valley plots.

	Fern Valley	Jungle Fall
Number of species >= 2 cm dbh	171	214
Number of families	39	49
Number of individuals >= 2 cm dbh	564	1000
Total basal area (m^2/ha)	22.3	28.9
% stems >= 2 cm dbh with attached climbers >= 1.4 m tall	25.1	39.7
Number of climbers >= 2 cm dbh	55	47
Number of climbers <2 cm dbh & >= 1.4 m tall	334	938
Total climbers per stem >= 2 cm dbh	0.71	0.46
Number of woody climbers >= 2 cm dbh	27	45
Number of monocot climbers >= 2 cm dbh (Palmae)	28	2
Number of monocot climbers <2 cm dbh & >= 1.4 m tall	11	214

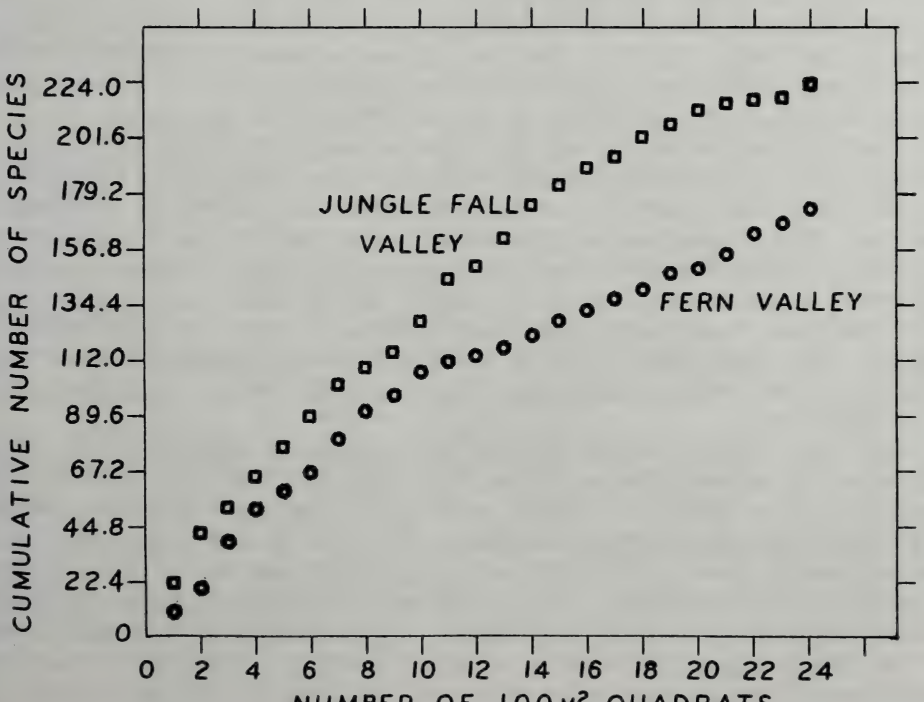

Fig. 4: Species area curves for the Fern Valley (plot F) and Jungle Fall Valley (plot J) plots.

mountain ranges of the Malay Peninsula and nearly down to sea level on coastal hills. Its canopy leaves are hard and waxy and have a high albedo, giving it some drought resistance.

Of the 25 species of greatest basal area in the Fern Valley plot (Table 2), 15 had one or more stems > = 20 cm dbh but zero or one individual in the 2–10 cm dbh size class. Comparable values in the Jungle Fall Valley plot were nine of 24 species (Table 3). A study of larger plot sizes is needed to determine whether reproduction of these species is taking place anywhere in the forest reserve under current environmental conditions.

Gironniera parvifolia (Ulmaceae) was the most numerous woody species in Jungle Fall Valley (43 stems, Table 5) and was the eighth most numerous species in Fern Valley (9 stems, Table 4). The largest individuals were 13 cm dbh in Jungle Fall Valley and 79 percent of the stems were in the 2–10 cm dbh size class. In Fern Valley, the largest stem was 17 cm dbh, and 67 percent of the stems were in the 2–10 cm dbh size class. It occupied a central position along the elevational gradient in Fern Valley (#8, Fig. 5) and a slightly higher position in Jungle Fall Valley (#1, Fig. 6). Because of its abundance under current conditions, I postulate that it is a shade tolerant species that has increased under conditions of minimal disturbance. The same explanation may apply to *Santiria apiculata* (Burseraceae), the third most abundant woody species in Jungle Fall Valley.

Urophyllum hirsutum was the most numerous species of sapling-size woody plant (treelet) in both plots and showed highly significant clumping by the test of Clark and Evans (1954) (Tables 4–7). It occupied a high average slope position in both plots (#1, Fig. 5 and #2, Fig. 6), indicating greater reproductive success than other species under upper elevational soil conditions.

The arborescent palm, *Oncosperma horridum*, and at least two species of climbing palms or rattans (*Calamus* sp. and *Daemonorops* sp.) were the next most numerous stems in Fern Valley (Table 4). *Oncosperma* was not present in Jungle Fall Valley or its vicinity. Historical accident could have played a part in the absence of *Oncosperma* from Jungle Fall Valley as well as different soil conditions.

More frequent tree falls in Fern Valley than in Jungle Fall Valley may be a factor that has aided the growth of rattans, which were especially dense in the northwest portion of the Fern Valley plot around three fallen trees. During the 11 months of this study, three tree falls occurred in the Fern Valley plot (one standing dead *Shorea curtisii* from outside the plot and two live trees within the plot belonging to the species *Ixonanthes icosandra* and *Eugenia duthieana*). No tree falls occurred in the Jungle Fall Valley plot. There was no significant difference between the two plots in total length of fallen dead stems > = 20 cm in diameter. If soils are thinner in Fern Valley than Jungle Fall Valley, a higher rate of uprooting of live trees could be expected to continue there.

There were large differences between the two plots in numbers of both woody (lianes) and herbaceous climbing plants. The Jungle Fall Valley plot had 67% more lianes > = 2 cm dbh (45 or 188/ha vs. 27 or 112/ha) and 181% more climbers <2 cm dbh (woody and herbaceous stems = 938) than the Fern Valley plot (woody and herbaceous stems = 334). While the Fern Valley plot had 28 climbing palms (*Calamus* and *Daemonorops*) > = 2 cm dbh and 11 Araceous climbers <2 cm dbh, Jungle Fall Valley had two climbing palms > = 2 cm dbh but 214 Araceous climbers <2 cm dbh. I suggest that these differences in numbers of climbers may indicate significant differences between the two plots in available moisture as influenced by soil depth. Putz and Chai (1987) found 164 and 348 woody vines/ha >2 cm dbh in hilltop and valley study plots respectively within primary dipterocarp forest in Lambir National Park, Sarawak, Malaysia.

Table 2
Distribution by size class of plant species with stems contributing the most basal area in the Fern Valley plot.

Species	Basal Area	Distribution by dbh size classes (cm)				
	(cm^2)	2–10	10–20	20–30	30–40	40+
Shorea curtisii	9,164	5	0	0	0	1
Pertusadina eurhyncha	7,235	0	0	0	0	1
Oncosperma horridum	5,174	9	21	2	0	0
Pellacalyx saccardianus	3,494	7	1	0	1	1
Artocarpus lanceifolius	2,952	0	0	0	0	1
Dipterocarpus penangianus	1,913	4	3	1	1	0
Meiogyne virgata	1,507	0	0	0	0	1
Gluta wallichii	1,265	1	0	0	1	0
Castanopsis lucida	1,251	0	0	0	0	1
Adenanthera bicolor	1,226	0	0	0	0	1
Litsea castanea	1,140	0	0	0	0	1
Licania splendens	1,123	0	0	0	0	1
Dalbergia parviflora	759	1	1	1	0	0
Artocarpus lowii	755	0	0	0	1	0
Myristica cinnamomea	743	3	2	1	0	0
Ixonanthes icosandra	660	0	0	1	0	0
Calophyllum ferrugineum	651	1	0	1	0	0
Gironniera parvifolia	580	6	3	0	0	0
Santiria sp.	491	0	0	1	0	0
Eugenia longiflora	491	0	0	1	0	0
Polyalthia angustissima	469	1	0	1	0	0
Santiria apiculata	439	5	0	1	0	0
Macaranga triloba	419	7	2	0	0	0
Tabernaemontana peduncularis	410	7	1	0	0	0
Eugenia densiflora	394	3	0	1	0	0
146 other species	8,829	445 stems in all size classes				
Totals	53,534	564 stems in all size classes				

Table 3
Distribution by size class of plant species with stems contributing the most basal area in the Jungle Fall Valley plot.

Species	Basal Area	Distribution by dbh size classes (cm)				
	(cm²)	2–10	10–20	20–30	30–40	40+
Shorea curtisii	15,469	23	0	0	0	3
Shorea parvifolia	7,860	1	0	0	0	1
Shorea macroptera	7,405	2	1	1	1	1
Gluta wallichii	4,232	5	1	2	1	1
Santiria griffithii	3,087	2	0	0	1	1
Dillenia grandifolia	1,752	2	1	0	0	1
Crypteronia cumingii	1,603	2	0	0	0	1
Gironniera parvifolia	1,366	34	9	0	0	0
Ixonanthes icosandra	1,046	1	0	2	0	0
Dacryodes sp.	962	0	0	1	0	0
Adenanthera bicolor	908	0	0	1	0	0
Shorea gratissima	888	0	1	1	0	0
Aporusa benthamiana	836	7	1	1	0	0
Planchonella maingayi	707	0	0	1	0	0
Artocarpus rigidus	707	0	0	1	0	0
Strombosia ceylanica	651	20	3	0	0	0
Cyathocalyx remuliflorus	639	9	2	0	0	0
Garcinia griffithii	601	6	0	1	0	0
Euodia glabra	589	1	0	1	0	0
Eugenia duthieana	563	7	3	0	0	0
Xylopia malayana	549	3	2	0	0	0
Knema laurina	542	21	1	0	0	0
Memecylon megacarpum	504	4	2	0	0	0
Scorodocarpus borneensis	452	0	0	1	0	0
Unidentified climbers	425	34	0	0	0	0
190 other species	14,920	765 stems in all size classes				
Totals	69,263	1,000 stems in all size classes				

Table 4
Relative density and distribution by dbh size class
of the most numerous species in the Fern Valley plot.

Species	Relative Density	Distribution by dbh size classes (cm)		
	(%)	2–10	10–20	20+
Urophyllum hirsutum	6.2	35	0	0
Oncosperma horridum	5.9	9	21	2
Calamus-Daemonorops	5.1	28	0	0
Ganua kingiana	4.0	22	0	0
Koilodepas wallichianum	3.5	19	0	0
Urophyllum streptopodium	2.6	14	0	0
Pellacalyx saccardianus	1.8	7	1	2
Dipterocarpus penangianus	1.6	4	3	2
Gironniera parvifolia	1.6	6	3	0
Streblus elongatus	1.6	8	1	0
Macaranga triloba	1.6	7	2	0
Urophyllum glabrum	1.5	8	0	0
Tabernaemontana peduncularis	1.5	7	1	0
Dacryodes rostrata	1.5	8	0	0
Knema laurina	1.5	7	1	0
Aporusa symplocoides	1.3	5	2	0
Blumeodendron tokbrai	1.1	6	0	0
Polyalthia sp.	1.1	5	1	0
Myristica cinnamomea	1.1	3	2	1
Shorea curtisii	1.1	5	0	1
Santiria apiculata	1.1	5	0	1
Hopea mengarawan	1.1	6	0	0
148 other species	296 stems in all size classes			
Total	564 stems in all size classes			

Table 5
Relative density and distribution by dbh size classes
of the most numerous species in the Jungle Fall Valley plot.

Species	Relative Density	Distribution by dbh size classes (cm)		
	(%)	2–10	10–20	20+
Gironniera parvifolia	4.3	34	9	0
Urophyllum hirsutum	4.2	42	0	0
Santiria apiculata	2.8	29	0	0
Koilodepas wallichianum	2.7	27	0	0
Santiria laevigata	2.7	27	0	0
Shorea curtisii	2.6	23	0	3
Dyera costulata	2.5	25	0	0
Buchanania sessilifolia	2.3	25	0	0
Strombosia ceylanica	2.3	20	3	0
Calamus-Daemonorops	2.2	22	0	0
Knema laurina	2.2	21	1	0
Baccaurea parviflora	2.0	20	0	0
Phaeanthus ophthalmicus	1.9	20	0	0
Ganua kingiana	1.8	18	0	0
Popowia fusca	1.4	17	0	0
Ardisia teysmanniana	1.3	14	0	0
Pimeleodendron griffithianum	1.2	11	1	0
Gcnystylus confusus	1.1	13	0	0
Glycosmis chlorosperma	1.1	12	0	0
Calophyllum tetrapterum	1.1	11	0	0
Cyathocalyx remuliflorus	1.1	9	2	0
Myristica cinnamomea	1.0	9	1	0
Gynotroches axillaris	1.0	9	1	0
Gluta wallichii	1.0	5	1	4
Eugenia duthieana	1.0	7	3	0
190 other species		530 stems in all size classes		
Total		1,000 stems in all size classes		

Table 6

Summary of clumping tests for woody species in Fern Valley with 5 or more stems. One asterisk indicates significance at $P < 0.05$ and two asterisks, significance at $P < 0.01$. Three indices of aggregation are compared: c — Clark and Evans (1954); I — Grieg-Smith (1982); and z — Johnson and Zimmer (1985). Significantly negative *c* values indicate positive skewness and thus clumping, while significantly positive values indicate nearest neighbour distances greater than expected by chance.

Species	n	c	z	I	Growth Form
1. Urophyllum hirsutum	32	−5.06**	−0.77	20.54	Treelet
2. Oncosperma horridum	32	—	−0.89	—	Tree palm
3. Ganua kingiana	22	−0.57	1.35	44.96**	Treelet
4. Koilodepas wallichianum	19	−1.07	3.09**	51.31**	Treelet
5. Urophyllum streptopodium	14	−9.19**	−0.56	16.59	Treelet
6. Pellacalyx saccardianus	10	0.87	−0.78	23.54**	Tree
7. Dipterocarpus penangianus	9	−0.44	0.93	39.12**	Large tree
8. Gironniera parvifolia	9	−0.32	—	14.65	Tree
9. Streblus elongatus	9	0.82	—	6.70	Large tree
10. Macaranga triloba	9	0.82	−0.63	75.10**	Small tree
11. Knema laurina	8	0.42	−0.74	48.95**	Tree
12. Urophyllum glabrum	8	−0.02	—	79.78**	Treelet
13. Tabernaemontana peduncularis	8	0.73	1.55	13.56	Treelet
14. Dacryodes rostrata	8	−2.31*	−0.04	7.93	Large tree
15. Aporusa symplocoides	7	0.27	—	48.65**	Treelet
16. Myristica cinnamomea	6	−1.00	2.72**	12.08	Tree
17. Blumeodendron tokbrai	6	1.75	−0.13	40.06**	Large tree
18. Santiria apiculata	6	2.08*	−0.76	10.48	Small tree
19. Hopea mengarawan	6	0.57	—	23.30**	Large tree
20. Shorea curtisii	6	−2.42*	−1.34	5.50	Large tree
21. Dehaasia sp.	5	−0.31	—	16.92**	Tree
22. Canarium sp.	5	−0.80	—	9.72	Tree
23. Xanthophyllum eurhynchum	5	−1.21	−0.35	6.48	Tree
24. Ardisia teysmanniana	5	−4.43**	—	2.13	Small tree
25. Medusanthera affinis	5	−1.05	—	7.51	Treelet
26. Horsfieldia sp.	5	−0.12	−0.39	18.50**	Large tree
Percentage clumped			12.5	48%	
+ Skewed		20%			
− Skewed		4%			
Randomly dispersed		76	87.5%	52%	

Table 7

Summary of clumping tests for woody species in Jungle Fall Valley with 5 or more stems. One asterisk indicates significance at $P<0.05$ and two asterisks, significance at $P<0.01$. Three indices of aggregation are compared: c — Clark and Evans (1954); I — Grieg-Smith (1982); and z — Johnson and Zimmer (1985). Significantly negative *c* values indicate positive skewness and thus clumping, while significantly positive values indicate nearest neighbour distances greater than expected by chance. Numbers may be slightly less than in Table 5 due to elimination of stems one metre or less from the edge of the plot.

Species	n	c	z	I	Growth Form
1. Gironniera parvifolia	43	3.46**	−1.57	78.49**	Tree
2. Urophyllum hirsutum	42	−7.56**	0.96	30.84	Treelet
3. Santiria apiculata	28	0.86	−0.40	36.78	Small tree
4. Santiria laevigata	27	1.14	−0.81	28.65	Large tree
5. Koilodepas wallichianum	27	−2.44**	−0.66	56.10**	Treelet
6. Shorea curtisii	26	−1.83	−0.36	21.32	Large tree
7. Dyera costulata	25	−1.61	−0.39	36.38	Large tree
8. Buchanania sessilifolia	23	−1.63	0.82	66.55*	Tree
9. Strombosia ceylanica	23	−0.80	0.8	47.14**	Small tree
10. Knema laurina	22	−0.54	0.14	55.10**	Tree
11. Baccaurea parviflora	20	−0.25	2.39*	21.90	Small tree
12. Phaeanthus ophthalmicus	19	−3.68**	3.60**	113.26*	Small tree
13. Ganua kingiana	18	−2.92**	0.14	13.19	Treelet
14. Popowia fusca	14	0.65	−0.02	16.67	Tree
15. Ardisia teysmanniana	13	0.92	0.19	93.02**	Small tree
16. Pimeleodendron griffithianum	12	−1.58	0.04	50.79**	Tree
17. Gonystylus confusus	11	−2.05*	0.90	5.33	Treelet
18. Glycosmis chlorosperma	11	1.16	—	46.76**	Treelet
19. Calophyllum tetrapterum	11	1.98*	−0.41	8.58	Tree
20. Cyathocalyx remuliflorus	11	−1.03	−1.23	52.10**	Tree
21. Myristica cinnamomea	10	0.24	—	38.1**	Tree
22. Gynotroches axillaris	10	−1.93*	0.68	43.42**	Tree
23. Gluta wallichii	10	0.29	0.11	42.46**	Large tree
24. Eugenia duthieana	10	1.79	0.69	32.3	Tree
25. Gomphandra quadrifida	9	0.16	−1.38	17.24	Treelet
26. Anisoptera megistocarpa	9	3.14**	—	21.02*	Large tree
27. Litsea accedens	9	1.65	—	62.31**	Tree
28. Aporusa benthamiana	9	1.27	—	5.10	Tree
29. Macaranga triloba	9	−3.57**	0.83	136.01**	Small tree

(Cont'd opposite page)

Table 7 *(Cont'd)*

Species	n	c	z	I	Growth Form
30. Payena lucida	8	3.16**	−0.15	11.38	Treelet
31. Palaquium microphyllum	8	2.18*	0.25	19.26**	Tree
32. Ardisia colorata	8	1.07	−1.07	22.97**	Small tree
33. Polyalthia sumatrana	8	0.28	0.30	51.71**	Tree
34. Unknown Meliaceae	7	−2.36**	−0.39	34.68**	Tree
35. Calophyllum ferrugineum	7	1.47	—	27.77**	Tree
36. Garcinia griffithii	7	−1.26	—	8.66	Tree
37. Randia densiflora	6	0.25	0.11	34.97**	Partial liana
38. Memecylon megacarpum	6	0.13	—	20.02**	Treelet
39. Shorea macroptera	6	−0.31	0.004	3.03	Large tree
40. Polyalthia angustissima	6	−0.66	—	37.06**	Small tree
41. Aporusa microstachya	6	1.54	−1.29	26.24**	Treelet
42. Gaertnera grisea	5	0.10	—	4.67	Shrub
43. Microcos blattaefolia	5	0.71	—	3.63	Small tree
44. Eugenia longiflora	5	2.22**	—	5.39	Tree
45. Hopea mengarawan	5	−1.45	—	0.29	Large tree
46. Archidendron sp.	5	1.00	—	18.19**	Small tree
47. Cnestis platantha	5	−2.91**	—	1.86	Liana
48. Prunus polystachya	5	0.34	—	60.90*	Tree
49. Actinodaphne malaccensis	5	−1.52	0.75	13.21*	Tree
Per cent clumped			6.1%	57.1%	
+ Skewed		18.4%			
− Skewed		12.2%			
Randomly dispersed		69.4%	93.9%	42.9%	

Tests of Dispersion

There are no records of major disturbances from fire, typhoons or earthquakes in the Bukit Timah Forest Reserve in the past 100 years. Therefore the degree of clumping should be high due to the presence of regeneration patches from tree falls (Pickett 1983), the most common form of disturbance (Armesto et al. 1986).

Three tests of dispersion were used to evaluate the degree of clumping in all species with > = 5 stems per plot [Clark and Evans (1954), Grieg-Smith (1983), and Johnson and Zimmer (1985)]. By use of that criterion, 26 species were analysed in Fern Valley (Table 6) and 49 in Jungle Fall Valley (Table 7). The test of Grieg-Smith (1983) declared more species to be significantly clumped than the other two methods (48 and 57.1% for Fern Valley and Jungle Fall Valley respectively.

Drought Deciduousness

Several species showed adaptations for deciduousness during the 1982–83 drought. I observed one large individual of each of four species of trees, *Parkia speciosa, Anisoptera megistocarpa, Parishia sp.,* and *Planchonella maingayi,* become leafless for a period of 3–6 weeks, and lianes also shedding many leaves. The large variation in annual rainfall from 1969 to 1983 (4007–1642 mm/yr) probably is typical of past variability. Holttum (1953) stated that over the previous 46 yr there had been 21 months with less than 6.2 cm of rain.

Future Trends in Forest Composition

The study plots and the reserve itself represent a mature phase rain forest (Whitmore 1984) in a "state of structural and dynamic non-equilibrium" (Ho et al. 1987: 51, Hartshorn 1980). Features of a mature phase rain forest include abundant seedlings and saplings of at least some tree species attaining the canopy, many tree, sapling and seedling size classes represented, low light intensities on the forest floor, a lack of disturbance from fire and domestic animals, and minimal disturbance from humans.

The small size of my study plots make it difficult to predict future changes in tree species composition on the two areas. Reproduction of the more important tree species must be studied over a larger area and longer period of time. *Shorea curtisii* dominated both plots in basal area and had some saplings in the smallest size class (Tables 2 and 3). However, eleven species in Fern Valley and five in Jungle Fall Valley were represented by one large individual and no representation in the two smallest size classes (Tables 2 and 3), while other species of mid-size and large trees were represented by seedlings and saplings but no mature individuals, such as *Pentace triptera* in Fern Valley and *Santiria laevigata* and *Dyera costulata* in Jungle Fall Valley. Wong (1987) reported finding 3, 8 and 1 individuals of these species respectively of gbh > = 12 inches in his sample of 889 trees in a 3.24 ha area of the reserve. *Dyera costulata* has been identified as a colonizer of gaps (Poore 1968) and a strong, light demanding species (Whitmore 1973).

A low number of adult individuals of other known light-demanding species persisted in the study plots without regeneration, such as *Macaranga triloba* (nine stems in each plot), and *Ixonanthes icosandra*, a long-lived pioneer according to Ho et al. (1987). According to Hartshorn (1978), such tree species with little or no regeneration may be gap species that are normally present in mature rain forest. Knight (1975) concluded that the tropical forest reserve on Barro Colorado Island, Panama, had not reached a climax equilibrium state after 130 yr of development and that in the older part of the forest several species of trees probably depended on wind-created canopy gaps for their persistence.

Evidence for Niche Differentiation

The graphs of slope position of 26 species in the Fern Valley plot and 49 in the Jungle Fall Valley plot (Figs. 5 & 6) provide some evidence for niche separation of woody species on hilly topography. These data support the position of Ashton (1976) regarding mixed dipterocarp forest in the Malayan lowlands "that floristic variation is unequivocally and consistently correlated principally with environmental factors, among which physiography is clearly important." *Shorea curtisii*, a ridgetop species according to Whitmore (1984), occurred at a more extreme upper right position in the Fern Valley (#20, Fig. 5) than in the Jungle Fall Valley graph (#6, Fig. 6). The Fern Valley plot is more eroded and dissected than the Jungle Fall Valley plot and may offer an environment more like ridgetop conditions than Jungle Fall Valley would. Ashton (1978) described the differences between the canopy and sapling leaves of *Shorea curtisii* and suggested that the mature phase canopy trees had evolved characteristics to cope with moisture stress over a long lifetime. Dipterocarps in Sarawak and Brunei appear to have strong site-specificity (Ashton 1964, 1969 and Brunig 1973).

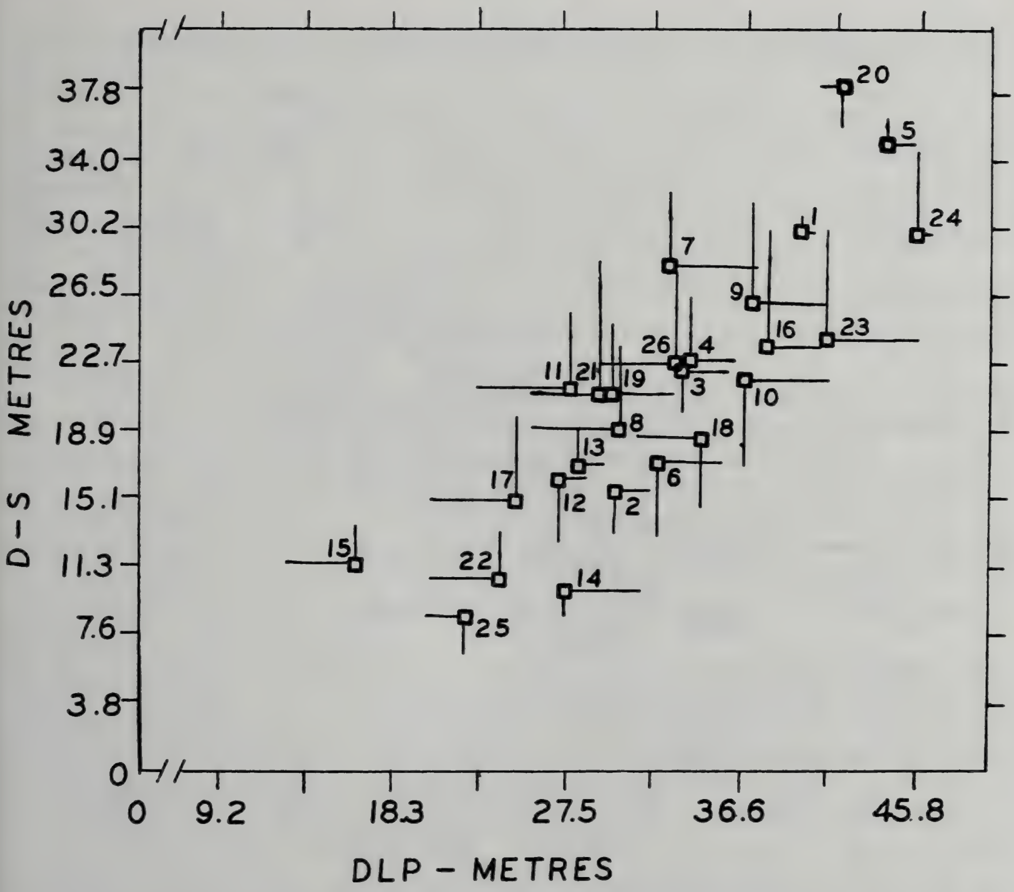

Fig. 5: Regression of the locations of stems of 26 woody species in the Fern Valley plot in which mean perpendicular distance to the drainage path (D-S) is plotted against mean distance to the lowest point in the plot (DLP). Single lines indicate one SE. Species numbers correspond to those in Table 6. Multiple r = 0.85286, F = 32.015, 1/12 DF, $P<0.002$, two-sided test.

Of those species that were numerous in both plots, some displayed similar mean elevational positions and some did not. *Gironierra parvifolia* (#8 in Fig. 5 and #1 in Fig. 6) occupied a similar mean elevational position to *Shorea curtisii* in the Jungle Fall Valley plot, but their positions were widely separated in Fern Valley. *Urophyllum hirsutum* occupied a high elevational position in both plots. *Knema laurina,* listed by Ho et al. (1987) as a common understory species of Malayan rain forests, occupied similar central positions in both plots (#11 in Fig. 5 and #10 in Fig. 6). On the other hand, *Ardisia teysmanniana,* a small tree, had a high position in Fern Valley (Fig. 5, #24) and a low position in Jungle Fall Valley (Fig. 6, #15). *Pimeleodendron griffithianum* occupied a low mean elevational position in Jungle Fall Valley (lower left corner of Fig. 6, #16), presumably the wettest location. Ho et al. (1987) listed it as a widely distributed species in lowland dipterocarp forest typically found in swampy soils.

Differences in behavioural characteristics and environmental requirements other than slope position may be especially important in reducing competition between two or more species in the same genus when these species are abundant in the same small

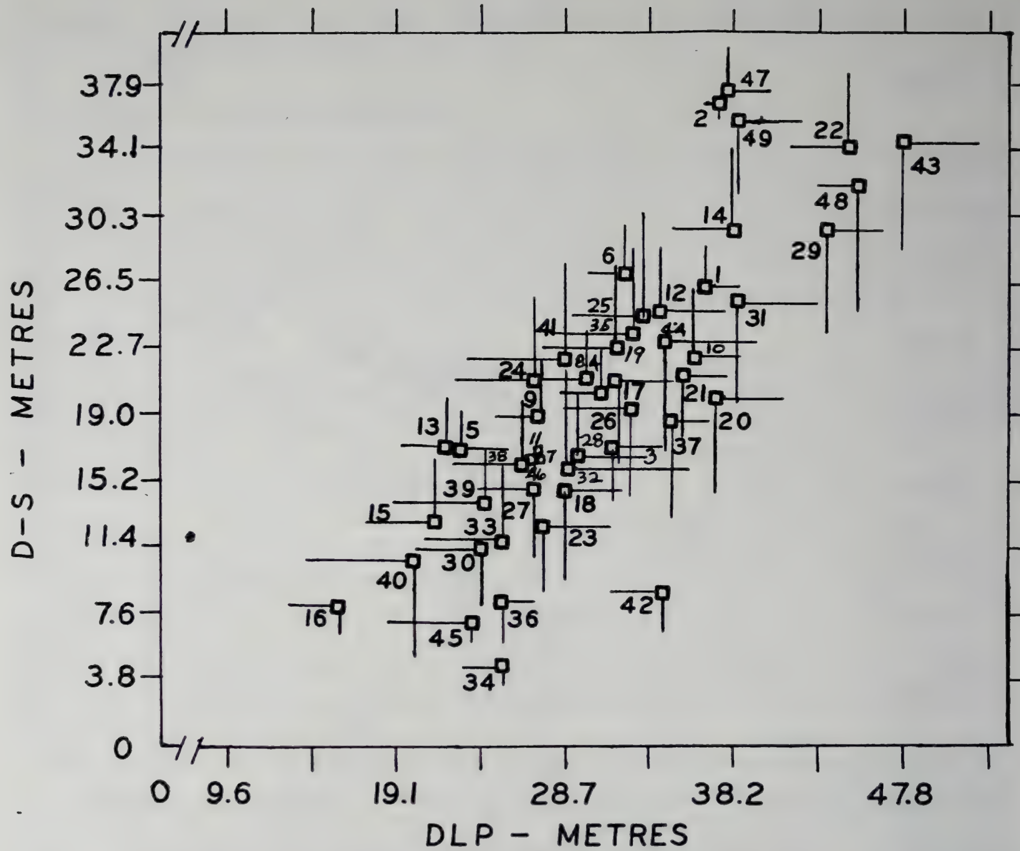

Fig. 6: Regression of the locations of stems of 49 woody species in the Jungle Fall Valley plot in which mean perpendicular distance to the estimated drainage path (D-S) is plotted against mean distance to the lowest point in the plot (DLP). Single lines indicate one SE. Species numbers correspond to those in Table 7. Multiple r = 0.65364, F = 8.9516, 1/12 DF, $P<0.05$, two-sided test.

area. In the Fern Valley plot (Fig. 5), three species of *Urophyllum,* all treelets, (*U. hirsutum*-#1, *U. streptopodium*-#5, and *U. glabrum*-#12) differed significantly in slope position. However, two other pairs of species in Jungle Fall Valley (*Eugenia longiflora*-#44, *E. duthieana*-#24, *Ardisia colorata,* #32 and *A. teysmanniana*-#15) did not differ significantly in slope position between species within a genus.

The Need for Forest Conservation

Based on the 11 months I spent studying the Bukit Timah Forest Reserve, I have become concerned that a nature reserve of only 71 ha would be in grave danger of gradually losing its rarer species because of accidents to one or a few remaining individuals or because of poor reproduction (Lovejoy et al. 1983). According to Lovejoy and Oren (1981), there is some support for the hypothesis that small fragments of ecosystems gradually become impoverished due to a predictable, sequential loss of species and possible invasion by weedy species. At Bukit Timah, the lack of the original complement of animal species, human encroachments on the reserve due to bull-dozing and quarrying of rock around its periphery, and intensive use as a city park all threaten the health of this valuable, small reserve. May (1986: 1121) stated, "in so far as any mathematical generalization exists, it is that randomly constructed ecosystems are likely to become less stable — more prone to fluctuation and less able to recover from disturbance — as they become more complex...."

The number of species of animals that once dispersed seeds in the Singapore area must be greatly reduced over that prior to 20,000 yr B.P. Absent species in the Holocene might well include gibbons, langurs, elephants, bovids, rhinoceros, tapirs, and pigs (Janzen 1978). Janzen (1970, 1974, 1975, 1978) has described the interaction of herbivores with tropical tree species, the irregular but abundant flowering and fruiting of the dipterocarps, and their chemical defences in the form of resins and gums. Putz (1979) stated that various animal species dispersed the seeds or fruits of 90% of the canopy tree species at the Bukit Lanjan study area 25 km northeast of Kuala Lumpur, Malaysia.

Ricklefs (1987) urged ecologists to study communities from a regional and historical point of view. Broad regional processes over more than 80 million yr have produced an unusually high diversity of flowering plant species in Southeast Asia (Fedorov 1966). Keng (1970) estimated that there are 8000 to 8500 plant species in the Malay Peninsula. Plant conservation in Southeast Asia will require much cooperation between Thailand, Malaysia, Singapore and Indonesia to establish a series of reserves, each including a continuum of communities from high to low elevations and thus to avoid the disastrous consequences of having only a small number of isolated fragments by the 21st century.

The Republic of Singapore is on the threshold of becoming a major biotechnology center of Southeast Asia. The more species of plants that can be grown in their natural setting with reproductively viable populations, the greater will be the opportunities for genetic manipulation of a vast treasure house of plant species and for future restoration of moist tropical forest to degraded land.

It would be prudent therefore to protect and upgrade the nature reserve by the following actions: establishment of 1) a stable buffer zone between the reserve and rock and earth-moving activities nearby and 2) special plantations to propagate rare species and others now extinct in Singapore so that plant species could be introduced into suitable habitats from which they have disappeared.

The great advances that have been made in tissue culture, cell hybridization, and genetic engineering have provided additional, urgent reasons for plant conservation and for understanding the processes that sustain plant communities. The Republic of Singapore has the scientific resources to capitalize on the enormous wealth of plant species for food crops, enzymes, hormones, medicinal drugs, timber, and ornamentals. Now is the time to act on the establishment, preservation and improvement of nature reserves.

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References

Armesto, J.J., Mitchell, J.D. and Villagran, C. (1986). A comparison of spatial patterns of trees in some tropical and temperate forests. *Biotropica*, 18, 1–11.

Ashton, P.S. (1964). Ecological studies in the mixed dipterocarp forest of Brunei State. *Oxford For. Mem.*, 25.

_____. (1969). Speciation among tropical forest trees: some deductions in the light of recent evidence. *Biol. J. Linn. Soc.* 1, 155–196.

_____. (1976). Mixed dipterocarp forest and its variation with habitat in the Malayan lowlands: a re-evaluation at Pasoh. *Mal. Forester* 39, 56–72.

_____. (1978). Crown characteristics of tropical trees. Ch. 25 In Tomlinson, P.B. and Zimmermann, M.H. (Eds.). *Tropical Trees as Living Systems*, Cambridge University Press; 591–615.

Brunig, E.F. (1973). Species richness and stand diversity in relation to site and succession of forests in Sarawak and Brunei (Borneo). *Amazoniana* 4, 293–320.

Clark, P.J. and Evans, F.C. (1954). Distance to nearest neighbor as a measure of spatial relationships in populations. *Ecology* 35, 445–453.

Conner, E.F. and McCoy, E.D. (1979). The statistics and biology of the species-area relationship. *Am. Nat.* 113, 791–833.

Corlett, R.T. (1988). Bukit Timah: the history and significance of a small rain-forest reserve. *Environmental Conservation* 15 (1), 37–44.

Fedorov, A.A. (1966). The structure of the tropical rain forest and speciation in the humid tropics. *J. Ecol.* 54, 1–11.

Grieg-Smith, P. (1983). Quantitative Plant Ecology. *Studies in Ecology*, Vol. 9, 359 pp. Third Ed. Blackwell Scientific Publications.

Hartshorn, G.S. (1978). Tree falls and tropical forest dynamics. In Tomlinson, P.B. and Zimmermann, M.H. (Eds.). *Tropical Trees as Living Systems*, Cambridge University Press; 617–638.

_____. (1980). Neotropical forest dynamics. In Ewel, J. (Ed.). Tropical Succession. *Biotropica*, supplement to Vol. 12 (2), 23–30.

Hill, R.D. (1973). Land and Sea. Ch. 1 in Chuang, S.H. (Ed.). *Animal Life and Nature in Singapore*, Singapore University Press, Singapore; 9–26.

_____. (1977). The vegetation map of Singapore: a first approximation. *J. Trop. Geog.* 45, 26–33.

Ho, C.C., Newberry D. McC. and Poore, M.E.D. (1987). Forest composition and inferred dynamics in Jengka Forest Reserve, Malaysia. *J. Trop. Ecol.* 3, 25–56.

Holttum, R.E. (1953). Evolutionary trends in an equatorial climate. I. The climate of Singapore. *Symposia of the Society of Experimental Biology, Number VII, Evolution;* 159–173.

Ives, D.W. (1977). Soil map of Republic of Singapore. Scale 1:63360. New Zealand Soil Bureau Map 169, *New Zealand Soil Survey Report* 36, 15 pp. and map.

Janzen, D.H. (1970). Herbivores and the number of tree species in tropical forests. *Am. Nat.* 104, 501–528.

_____. (1974). Tropical blackwater rivers, animals, and mass fruiting by the Dipterocarpaceae. *Biotropica* 6:69–103.

_____. (1975). Ecology of plants in the tropics. *Studies in Biology* No. 58. Arnold Publishers Ltd., London, 66 pp.

_____. (1978). Seeding patterns of tropical trees. In Tomlinson, P.B. and Zimmermann, M.H. (Eds.). *Tropical Trees as Living Systems*, Cambridge University Press; 83–128.

Johnson, R.B. and Zimmer, W.J. (1985). A more powerful test for dispersion using distance measurements. *Ecology* 66, 1669–1675.

Keng, H. (1970). Size and affinities of the flora of the Malay Peninsula. *J. Trop. Geog.* 31, 43–56.

_____. (1973). Annotated list of seed plants of Singapore (I). *Gard. Bull. Sing.* 26, 233–237.

_____. (1974). Annotated list of seed plants of Singapore (II). II. Angiosperms-Dicotyledons. *Gard. Bull. Sing.* 27(1), 67–83, (2) 247–266.

_____. (1976). Annotated list of seed plants of Singapore (IV). Angiosperms-Dicotyledons (continued). *Gard. Bull. Sing.* 28(2), 237–258.

_____. (1978). Annotated list of seed plants of Singapore (V). II. Angiospermae-Dicotyledons (continued). *Gard. Bull. Sing.* 31, 84–113.

_____. (1980). Annotated list of seed plants of Singapore (VI). II. Angiospermae-Dicotyledons (continued). *Gard. Bull. Sing.* 33(2), 329–367.

_____. (1982). Annotated list of seed plants of Singapore (VII). II. Angiospermae-Dicotyledons (continued). *Gard. Bull. Sing.* 35(1), 83–103.

Knight, D.H. (1975). A phytosociological analysis of species-rich tropical forest on Barro Colorado Island, Panama. *Ecol. Monographs* 45, 259–284.

Lovejoy, T.E. and Oren, D.C. (1981). The minimum critical size of ecosystems. In Burgess, R.L. and Sharpe, D.M. (Eds.). *Forest Island Dynamics in Man-dominated Landscapes*, Ecological Studies-Analysis and Synthesis, Vol. 41. Springer-Verlag; 7–12.

_____, Bierregaard R.O., Rankin, J.M. and Schubart, H.O.R. (1983). Ecological dynamics of tropical forest fragments. In Sutton, S.L., Whitmore, T.C. and Chadwick, A.C. (Eds.). *Tropical Rain Forest: Ecology and Management*, Blackwell Scientific Publications, London: 377–384.

May, R.M. (1986). The search for patterns in the balance of nature: advances and retreats. *Ecology* 67, 1115–1126.

Nature Reserves Board. (1975). *Bukit Timah Nature Reserve*. Brochure with map. Singapore.

Pickett, S.T.A. (1983). Differential adaptation of tropical tree species to canopy gaps and its role in community dynamics. *Trop. Ecol.* 24, 68–84.

Poore, M.E.D. (1968). Studies in Malaysian Rain Forest. I. The forest on the Triassic sediments in Jengka Forest Reserve. *J. Ecol.* 56, 143–196.

Putz, F.E. (1979). Aseasonality in Malaysian tree phenology. *Mal. For.* 42, 1–24.

_____ and Chai, P. (1987). Ecological studies of woody vines in Lambir National Park, Sarawak, Malaysia. *J. Ecol.* 75, 523–531.

Ricklefs, R.E. (1987). Community diversity: relative roles of local and regional processes. *Science* 235, 167–171.

Whitmore, T.C. (Ed.) (1973). Apocynaceae. In *Tree Flora Malaya*. Vol. 2. Longman. Kuala Lumpur.

_____. (1984). *Tropical Rain Forests of the Far East*. 2nd Ed. Clarendon Press, Oxford. 352 pp.

Wong, P.P. (1969). The surface configuration of Singapore Island, a quantitative description. *J. Trop. Geog.* 29, 64–74.

Wong, Y.K. (1987). Ecology of the trees of Bukit Timah Nature Reserve. *Gard. Bull. Sing.* 40(1), 45–76.

Appendix

Species names and authorities, numbers of stems and basal areas (BA-cm^2) in the Fern Valley and Jungle Fall Valley plots. Obsolete scientific names are in parentheses.

Names	Fern Valley		Jungle Fall	
	No.	BA	No.	BA
Anacardiaceae				
Buchanania sessilifolia Bl.	1	29	23	420
Gluta wallichii (Hk. f.) Ding Hou	2	1,265	10	4,232
Parishia sp.	2	42	4	249
Annonaceae				
Cyathocalyx remuliflorus (Maingay et Hk. f. et Thoms.) Scheff.	0	0	11	639
Meiogyne virgata (Bl.) Miq.	1	1,507	0	0
Phaeanthus ophthalmicus (Roxb. ex Don) Sincl.	1	17	19	148
Polyalthia angustissima Ridley	2	469	6	227
Polyalthia sumatrana (Miq.) Kurz.	2	172	8	153
Polyalthia sp.	6	180	0	0
Popowia fusca King	0	0	14	302
Xylopia malayana Hk. f. & Thoms.	0	0	4	549
Apocynaceae				
Dyera costulata (Miq.) Hk. f.	0	0	25	402
Tabernaemontana peduncularis Wall.	8	410	0	0
Burseraceae				
Canarium sp.	5	46	1	13
Dacryodes rostrata (Bl.) H.J. Lam.	8	142	2	44
Dacryodes sp.	0	0	1	962
Santiria apiculata Benn.	6	439	28	219
Santiria griffithii (Hk. f.) Engl.	0	0	4	3,087
Santiria laevigata Bl.	1	6	27	258
Connaraceae				
Cnestis platantha Griff.	0	0	5	28
Dilleniaceae				
Dillenia grandifolia Wall. ex Hk. f. et Th.	0	0	4	1,752
Dipterocarpaceae				
Anisoptera megistocarpa Sloot.	1	6	9	196
Dipterocarpus penangianus Foxw.	9	1,913	0	0
Hopea mengarawan Miq.	6	130	5	117
Shorea curtisii Dyer	6	9,164	26	15,469
Shorea gratissima (Wall. ex Kurz.) Dyer	0	0	2	888
Shorea macroptera Dyer	1	14	6	7,405
Shorea parvifolia Dyer	2	140	2	7,860
Euphorbiaceae				
Aporusa benthamiana Hk. f.	0	0	9	836
Aporusa microstachya Arg.	1	5	6	70
Aporusa symplocoides (Hk. f.) Gage	7	288	1	16
Baccaurea parviflora Muell. Arg.	4	139	20	191

(Cont'd next page)

Appendix *(Cont'd)*

Names	Fern Valley No.	Fern Valley BA	Jungle Fall No.	Jungle Fall BA
Blumeodendron tokbrai (Bl.) Kurz	6	87	2	8
Koilodepas wallichianum Benth. f.	19	104	27	182
Macaranga triloba Muell. Arg.	9	419	9	89
Pimeleodendron griffithianum (Muell. Arg.) Benth.	3	32	12	316
Fagaceae				
Castanopsis lucida (Nees) Soepadmo	1	1,251	2	236
Gonystylacaceae				
Gonystylus confusus Airy Shaw	0	0	11	92
Guttiferae				
Calophyllum ferrugineum Ridl.	2	651	7	110
Calophyllum tetrapterum Miq.	0	0	11	94
Garcinia griffithii T. Anders	0	0	7	601
Lauraceae				
Actinodaphne malaccensis Hk. f.	2	32	5	23
Dehaasia sp.	5	31	0	0
Litsea accedens (Bl.) Boerl.	3	51	9	177
Litsea castanea Hk. f.	1	1,140	0	0
Leguminosae				
Adenanthera bicolor Moon	1	1,226	1	908
Archidendron sp.	0	0	5	48
Dalbergia parviflora Roxb.	3	759	0	0
Parkia speciosa Hassk.	0	0	2	19
Linaceae				
Ixonanthes icosandra Jack	1	660	3	1,046
Lythraceae				
Crypteronia cumingii (Planch.) Endl. var griffithii (Clarke) Osinga	0	0	3	1,603
Melastomataceae				
Memecylon megacarpum Furtado	0	0	6	504
Meliaceae				
Unidentified species	1	26	7	44
Moraceae				
Artocarpus lanceifolius Roxb.	1	2,952	0	0
Artocarpus lowii King	1	755	0	0
Artocarpus rigidus Bl.	0	0	1	707
Streblus elongatus (Miq.) Corner	9	266	1	4
Myristicaceae				
Horsfieldia sp.	5	82	2	57
Knema laurina Warb.	8	155	22	542
Knema sp.	10	131	0	0
Myristica cinnamomea King	6	743	10	337

(Cont'd opposite page)

Appendix *(Cont'd)*

Names	Fern Valley No.	Fern Valley BA	Jungle Fall No.	Jungle Fall BA
Myrsinaceae				
Ardisia colorata Roxb.	1	4	8	41
Ardisia teysmanniana Scheff.	5	92	13	187
Myrtaceae				
Eugenia densiflora Miq.	4	394	0	0
Eugenia duthieana King	4	68	10	563
Eugenia longiflora F.-Vill.	1	491	5	329
Olacaceae				
Gomphandra quadrifida (Bl.) Sleum	1	13	9	41
Medusanthera affinis (Miers.) Sleum	5	104	0	0
Scorodocarpus borneensis Becc.	1	154	1	452
Strombosia ceylanica Gardn.	3	46	23	651
Palmae				
Calamus — Daemonorops sp.	28	335	22	103
Oncosperma horridum Scheff.	10	5,174	0	0
Polygaceae				
Xanthophyllum eurhynchum Miq.	5	46	1	6
Rhizophoraceae				
Gynotroches axillaris Bl.	0	0	10	348
Pellacalyx saccardianus Scort.	10	3,494	0	0
Rosaceae				
Licania splendens (Korth.) Prance	1	1,123	1	5
Prunus polystachya (Hk. f.) Kalkman.	3	115	5	191
Rubiaceae				
Gaertnera grisea Hk. f. ex. Clarke	4	40	5	38
Pertusadina eurhyncha (Miq.) Ridsdale (Adina rubescens Hemsl.)	1	7,235	1	8
Randia densiflora Benth.	1	4	6	58
Urophyllum glabrum Wall. ex. Roxb.	8	132	1	15
Urophyllum hirsutum Hk. f.	32	231	42	406
Urophyllum streptopodium Wall.	14	106	1	5
Rutaceae				
Euodia glabra (Bl.) Bl.	0	0	2	589
Glycosmis chlorosperma Spr.	3	21	11	115
Sapotaceae				
Ganua kingiana (Brace) van den Assem	22	338	18	351
Palaquium microphyllum King & Gamb.	0	0	8	39
Payena lucida (Don.) DC	1	6	8	58
Planchonella maingayi (Clarke) van Royen	0	0	1	706
Tiliaceae				
Microcos (Grewia) blattaefolia Corner	0	0	5	90
Pentace triptera Mast.	4	20	1	23
Ulmaceae				
Gironniera parvifolia Planch.	9	580	43	1,607

Notes on the Early Exploration and Botanical Collecting in the Endau-Rompin Area of Peninsular Malaysia

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Abstract

The earliest scientific expeditions to the Endau area of Peninsular Malaysia were those by J.R. Logan (1847), N.N. Miklucho-Maclay (1874, 1875), D.F.A. Hervey (1879) and H.W. Lake (1891), although the first documented botanical collections from the area were made in 1892 by H.J. Kelsall during his visit with Lake. Kelsall's collecting localities included Gunung Janing and the Semberong River. Subsequent botanical visits to the area were made by personnel of the Forest Department of the Straits Settlements and Federated Malay States during the 1920s and 1930s and later by botanists and staff based at the Forest Research Institute at Kepong, the Singapore Botanic Gardens and the University of Malaya. A list is given of these collectors and those during expeditions organised to the Endau-Rompin area by the Malayan Nature Society in 1985-86, their collecting localities and periods. Mention is also made of the herbaria where these collections are curated. This information is presented as a background to future attempts at compiling resource inventories for the Endau-Rompin area, a significant portion of which is being proposed for conservation.

Introduction

Much scientific work has been carried out during the Malayan Nature Soceity's Malaysian Heritage and Scientific Expedition of 1985-86 to the Endau-Rompin area, where a significant portion of the Endau River basin is being proposed for conservation. In spite of this, it is not yet possible to provide a detailed inventory of the flora of the area, which will be important for management purposes. Botanical studies of the area began in the 19th century and a great many visits have been made to the area since then. This account brings together information on early exploratory visits to the area and the numerous recent botanical surveys carried out there until the end of the Expedition in June 1986, as a background for a comprehensive inventory of the flora in the future.

Early Scientific Visitors to the Endau Basin

The first scientific explorations of the Endau area took place in the 19th century when much of the Malay Peninsula was still poorly mapped. Skinner (1878), discussing the progress made in the geography of the Malay Peninsula, wrote in the Journal of the Straits Branch of the Royal Asiatic Society: "Of these ... journey's [sic!] so important to our Cartography, some record should here be made; more especially as no account of them has been published in a permanent or generally accessible form ... But it would be invidious not to refer also to certain earlier journeys, viz., that

. . . of Mr. Logan (via Singapore, Indau, Semrong, Blumut, and Johore in 1847 . . ." James Richardson Logan was a Scotsman and Barrister-at-Law, based in Penang and Singapore much of the time and interested in both geology and ethnology. He also founded the Journal of the Indian Archipelago and Eastern Asia, in which he wrote much about the livelihood of the Jakun people of Johore (Thomson 1881). His visit to the Endau River brought him only as far as its confluence with the Semberong River (some 15 km eastward from the boundary of the area presently proposed as the Endau-Rompin national park), and his exploration was mainly along the Semberong and southwards.

In 1874 the Russian geographer-ethnologist Nikolaj Nikolajewitsch Miklucho-Maclay undertook an exploration of epic proportions which brought him to the Endau River also. He set out on 15 December 1874, up the Muar River on the west coast of the Malay Peninsula, crossed southward to the Segamat River, made his way eastward to the Semberong River and went down the Endau River to the South China Sea. Thereafter he returned inland, explored the Kahang and Madek rivers, and continued southward along the Johor river to the Tebrau Straits which he reached on 2 February 1875 (Miklucho-Maclay 1875, 1878). In June 1875, Miklucho-Maclay embarked on a second journey, following his earlier course until the Endau-Semberong confluence, whence he travelled some 20 km further upriver on the Endau and climbed Gunong Janing (at the eastern boundary of the presently proposed Endau-Rompin park). However, he did not continue further up along the Endau, but instead turned seawards to the town of Pekan in Pahang, where he followed the Pahang river inland and emerged to Kota Baharu on the northeast coast, and finally inland again before arriving at the mouth of the Patani River. At this point, in October 1875, he was compelled to abandon the expedition because of the advancing monsoonal rains (Miklucho-Maclay 1878). Both Logan and Miklucho-Maclay appear not to have collected any botanical specimens from these journeys (van Steenis-Kruseman 1950).

Following this Dudley F.A. Hervey also visited the Endau area in August 1879, three years before he was to be Resident Councillor of Malacca (Hervey 1882). He travelled (presumably by sea) from Singapore to the mouth of the Endau River, and coursed along it only as far as where it met the Semberong River; he, too, turned southwards to explore the Semberong and its tributaries, the Kahang and the Madek, and made no further exploration of the Endau River itself. Hervey collected plants in his time, but appears not to have collected during his visit to the Endau-Semberong area (Burkill 1927, van Steenis-Kruseman 1950).

Most familiar to botanists are Harry Lake, miner and surveyor, and H.J. Kelsall, who was a Lieutenant with the Royal Engineers in Singapore, because of the plant specimens collected on their journey. Lake began his exploration of the Endau River on 13 August 1891, on instruction from the Sultan of Johor, because the Endau was at the time poorly known and existing maps then showed the river to be comparatively small, with its source just a little beyond G. Janing. Lake traced the source of the Endau to a point about 44⅔ miles (about 72 km) upstream from the Endau-Semberong confluence, near the base of G. Besar, and crossed over to the headwaters of the Segamat River. He continued northward to the Jekati River and eventually emerged at Muar on the west coast in early October (Lake 1894). Lake's expedition appears to be the first documented crossing of the Malay Peninsula from east to west via the Endau River; however he did not collect any plant specimens.

Lake returned with Kelsall for another cross-peninsula expedition starting from Kuala Endau on 17 October 1892, but this time following a different route. They went upstream on the Endau only as far as the Lemakoh River (whence Kelsall ascended and collected plants on G. Janing), and returned to the Semberong River which they followed upstream, eventually passing overland to the Bekok River and downstream to Batu Pahat on the west coast, which was reached on 5 November 1892 (Lake & Kelsall 1895). Kelsall collected plants on this expedition, mostly on the Semberong River, but these and his collections from G. Janing are important as reference material for the botany of the area. These specimens were presented to the herbarium of the Singapore Botanic Gardens where H.N. Ridley was able to name most of them (Lake & Kelsall 1895), and today these specimens are still curated in good condition at the herbarium there. The specimens were collected by Kelsall but are labelled "Lake and Kelsall's collections"; these specimens bear numbers that must have been given after the expedition because the numbers do not chronologically follow the dates of collection.

These are the pioneering scientific visits to the Endau area. Subsequent botanical visits to the area now proposed as the Endau-Rompin national park and its vicinity have not been well documented except through the plant specimens preserved in herbaria. In our discussions here of botanical collecting trips, the area of interest is taken as the proposed park area itself (about 45 km across at its widest east-west span) as well as a zone of about 15 km wide immediately surrounding the proposed park. The collecting localities of different collecting parties dealt with in this account are shown in Fig. 1; those localities visited before the Malayan Nature Society's 1985/1986 Endau-Rompin expedition are represented by symbols whereas collecting localities during the Society's expedition are represented by alphabets.

Twentieth-Century Visits: Before the 1985/86 Expedition

Probably the earliest botanical visit to the Endau-Rompin area this century was that of J.G. Watson and Yeob Abdul Rahim, of the Forest Department of the Straits Settlements and Federated Malay States, who in July 1923 collected plants along the Endau River east of Kuala Jasin. It was on this trip that Watson made the first collection of a riverbank shrub endemic to the Endau river basin and which was later named *Phyllanthus watsonii*, after him. Other early plant collectors who visited the area were mainly Forest Department staff, including Forest Guard Mohamud (at Sungai Kachah Putih, a tributary of the Rompin River, January 1930), Forest Guard Sudin (along the Sungai Anak Endau east of the proposed park area, March–November 1933), Forest Ranger Mohamed Said (Sungai Anak Endau, May 1935) and a number of other uniformed staff of the Forest Department (who each collected only one or several specimens on Gunung Lesong on the northern boundary of the proposed park area, April 1956).

Following this further botanical collections in the area were carried out by the following parties:

K.M. Kochummen, F.S.P. Ng (Forest Botanists) of the Forest Research Institute (FRI) at Kepong, and Forestry students of the Forest Department, July 1964, in Labis Forest Reserve just southwest of the proposed park area;

K.M. Kochummen and T. Suppiah (Herbarium assistant) of the FRI at Kepong, April 1967, southwest of the proposed park area;

T.C. Whitmore (Colombo Plan Botanist at the FRI at Kepong), May 1967, Bukit Peta and Sungai Endau in its vicinity;

P.F. Cockburn (British volunteer attached to the FRI at Kepong) and K. Ogata (botanist at the Tsukuba Forestry and Forest Products Research Institute), March–April 1968, Gunung Janing, Sungai Endau in its vicinity and Sungai Anak Endau;

P. Selvaraj (Herbarium assistant of the FRI at Kepong), November 1968, southwest of the proposed park area;

K.M. Kochummen, July and September 1970, southwest of the proposed park area;

T.C. Whitmore, T. Suppiah and Samsuri Ahmad (plant collector at the Singapore Botanic Garden), February 1971, in the vicinity of Sungai Ulu Pukin and Sungai Jekatih on the west side of the proposed park area;

Y.C. Chan (Herbarium assistant of the FRI at Kepong), March 1972, southwest of the proposed park area; June 1972, in the vicinity of Sungai Jekatih northwest of the proposed park area;

E.A. Heaslett (Singapore-based medical doctor and plant collector), Mohamad Shah (Herbarium assistant at the Singapore Botanic Garden), Ahmad Shukor and Samsuri Ahmad (plant collectors at the Singapore Botanic Garden), July 1972, Gunung Janing and Sungai Endau in its vicinity;

B.C. Stone (Botanist at the University of Malaya) and the Botany Class of 1973, August 1973, Bukit Peta and Sungai Endau in its vicinity;

Mohamad Shah, November 1973, Gunung Lesong;

J. Dransfield (Botanist at the Royal Botanic Gardens, Kew), June 1977, Gunung Janing;

Y.C. Chan and Kamarudin Saleh (Herbarium assistants at the FRI at Kepong), June 1979, in the vicinity of Sungai Jekatih northwest of the proposed park area;

K.M. Wong (Forest Botanist, FRI at Kepong), T.D. Pennington (Botanist at the Royal Botanic Gardens, Kew) and Kamarudin Saleh, September–October 1981, Bukit Peta and Sungai Kemelai just east of the proposed park area.

The collections of Heaslett, Mohamad Shah, Ahmad and Samsuri (July 1972) and of Mohamad Shah (November 1973) are principally deposited in the Herbarium of the Singapore Botanic Gardens (SING), with duplicates distributed to the herbaria at the Forest Research Institute of Malaysia at Kepong (KEP) and the Royal Botanic Gardens at Kew (K). Ogata's collections are principally housed at the Tsukuba Forestry and Forest Products Research Institute with duplicates at KEP. Pennington's collections are housed at K, and also duplicated at KEP. The collections of Stone are deposited in part in the Herbarium of the University of Malaya (KLU) and in the herbarium of the Academy of Natural Sciences of Philadelphia (PH); those of the University of Malaya 1973 Botany students who accompanied Stone are deposited at KLU. All other collections are principally deposited at KEP with main duplicates

Figure 1. (See opposite page)

Chan (Mar 1972 Labis For. Res., Jun 1972 Lesong For. Res.), Chan & Kamarudin (Jun 1979), ⊞ Cockburn & Ogata (Mar–Apr 1968), ☐ Dransfield (Jun 1977), Forest Dept., various uniformed staff (Apr 1956), Forestry Students with Kochummen & Ng (Jul 1964), O Heaslett, Mohamad Shah, Ahmad Shukor & Samsuri Ahmad (Jul 1972), ⊙ Kelsall & Lake (Oct 1892), ✱ Kochummen (Jul–Sep 1970), Kochummen & Suppiah (Apr 1967), ★ Mohamud (Jan 1930), Mohamad Said (May 1935), ♦ Mohamad Shah (Nov 1973), ☆ Selvaraj (Nov 1968), * Stone & University of Malaya 1973 Botany Class (Aug 1973), Sudin (Mar, Jun, Jul, Nov 1933), Watson & Yeob Abdul Rahim (Jul 1923), Whitmore (May 1967), Whitmore, Samsuri & Suppiah (Feb 1971), ⊞ Wong, Pennington & Kamarudin (Sep–Oct 1981); a (Base Camp & K. Jasin), b (G. Janing), c (K. Marong & K. Jasin area), all collectors who visited during the 1985–86 expedition (see text); d (Bukit Sengongong & "Buaya Sangkut" falls), P. Leong, Saw, Wong, e (Padang Temambun), Davison, B.H. Kiew, R. Kiew, Masrom, Nik Mohamed, Razali Baki, Saw, Wong, k (K. Kemapan), B.H. Kiew, R. Kiew, Saw, Wong, m (Sg. Kinchin), B.H. Kiew, n (Sg. Selai), B.H. Kiew, x (Kg. Peta & Sg. Endau), R. Kiew, Ng, Phang, Saw, Taylor, Wong, z (Sg. Endau between K. Kinchin & K. Jasin), R.P. Lim.

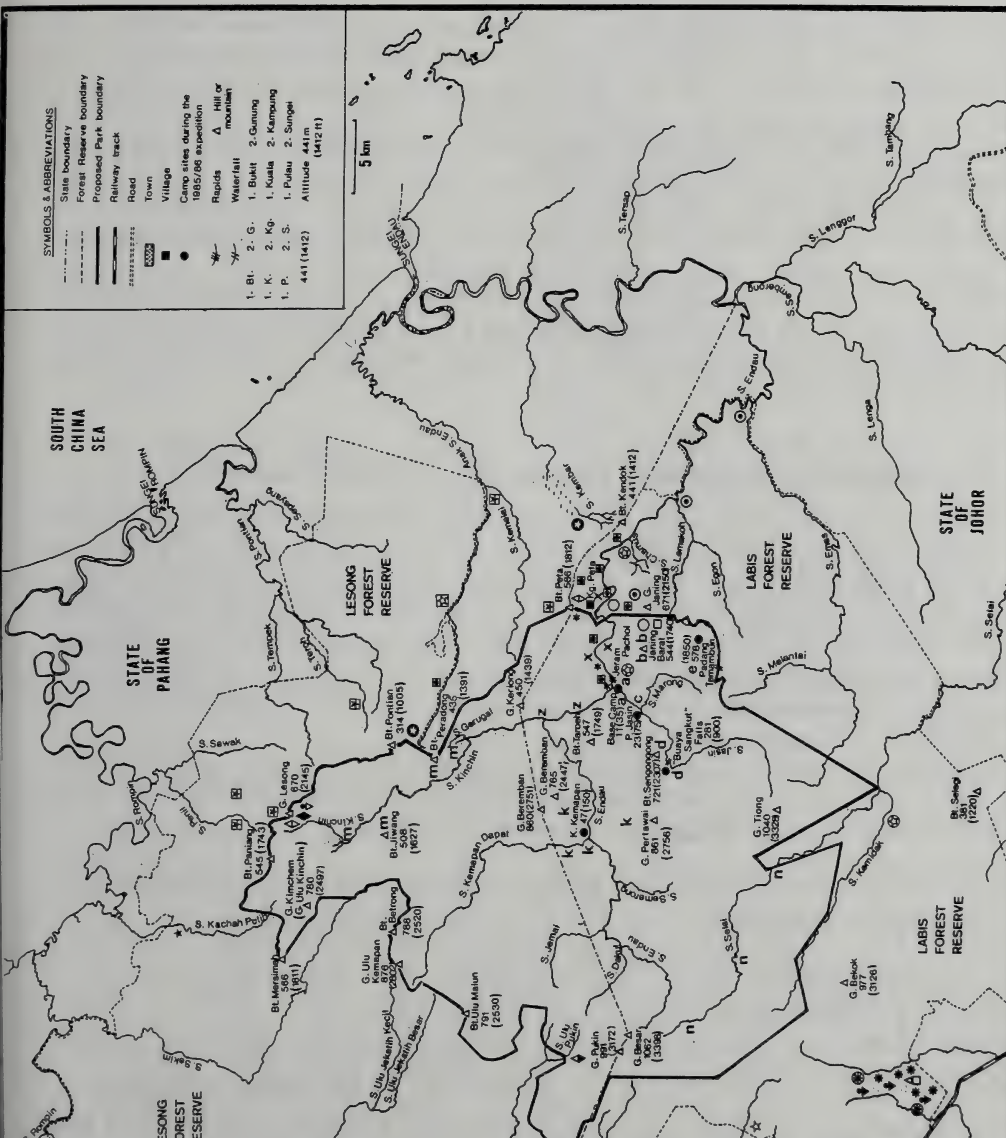

Fig. 1: Botanical collecting localities in the Endau-Rompin area prior to the Malayan Nature Society's 1985–86 Expedition (in symbols) and during the expedition period (represented by alphabets).

distributed to the Arnold Arboretum (A), Kew (K), Leiden (L), Sandakan (SAN), Kuching (SAR) and Singapore (SING).

As a note of interest, expeditions of a purely botanical nature have not been the only ones made to the Endau-Rompin area. Several other visits to the area have concerned the vegetation there. During 1965–1966, the Forest Research Institute's Forest Resources Reconnaissance Surveys of the Mersing, Rompin and Segamat districts by Cracium (1966), Lee (1966) and Gyekis (1966), respectively, included brief stand-assessments of the vegetation types found in the Endau-Rompin area. Flynn's survey of Sumatran Rhinoceros populations in the area (Flynn 1978) also included an enumeration of plant species known to be eaten by rhinos in the area. At the peak of concern over logging threats to the Endau-Rompin area in July 1977, three groups of Malayan Nature Society members visited the area; one group visited the Endau-Jasin area, another the Jemai-Kemapan area and a third carried out brief aerial surveys over the area, although apparently few or no plant specimens were collected during these visits.

Botanical Collecting During the 1985/86 Expedition

The Malayan Nature Society's Malaysian Heritage and Scientific Expedition to Endau-Rompin between June 1985 and June 1986 created the opportunity for greater botanical exploration of the area. In particular, the establishment of a base-camp at Kuala Jasin provided facilities for a nearly continuous stream of scientists and nature enthusiasts throughout this period and made repeated visits by scientists at different times of the year a convenient undertaking. The support of the Royal Malaysian Air Force also enabled a botanical team to be transported by helicopter to Kuala Kemapan, at the centre of the area.

Collectors of specimens for herbaria during the Expedition may be listed under the following institutions (the collecting periods, plant groups and herbaria where collections are kept are indicated after collectors' names).

(1) the Forest Research Institute of Malaysia (FRIM), Kepong (herbarium KEP) —
Aminuddin Mohamad .... 8–11 Oct 1985; palms, KEP
K.C. Ang .... 9–13 Sep 1985; dicots, KEP
Kamarudin Saleh .... 21–26 Oct 1985; dicots, KEP
K.M. Kochummen .... 5–10 Aug 1985; dicots, KEP
C.M. Low .... 8–11 Oct 1985; palms, KEP
Mat Asri .... 8–11 Oct 1985; palms, KEP
F.S.P. Ng .... 30 Jul–2 Aug 1985; dicots, ferns, KEP
L.G. Saw .... 5–10 Aug & 21–26 Oct 1985, 23 Apr–2 May & 25–31 May 1986; ferns, gymnosperms, angiosperms, KEP
K.M. Wong .... 5–10 Aug & 21–26 Oct 1985, 23 Apr–2 May & 23–31 May 1986; algae, bryophytes, pteridophytes, gymnosperms, angiosperms, KEP
S.K. Yap .... 9–13 Sep 1985; dicots, KEP

(2) the Malaysian Agricultural Research and Development Institute (MARDI), Serdang —
Abdullah Thani .... 24–28 Mar 1986; orchids, aroids, MARDI
W.H. Lim .... 24–28 Mar 1986; orchids, MARDI

Masron Hasran	20–25 Sep 1985, 7–16 Feb 1986; monocots, dicots, MARDI
Mishiyah Katman	20–27 Sep 1985; fungi, MARDI
Mohamad Hanifah	7–16 Feb 1986; dicots, MARDI
Mohamad Yassin	23–26 Jul 1985, 24–28 Mar 1986; orchids, MARDI
Mohammed Harun	7–16 Feb 1986; fungi, MARDI
M. Mooruthy	20–25 Sep 1985; orchids, MARDI
Nik Mohamed	7–16 Feb 1986; fungi, MARDI
Noorshinah Hussin	20–27 Sep 1985, 7–16 Feb 1986; fungi, MARDI
Razali Baki	23–26 Jul 1985, 7–16 Feb 1986; monocots, dicots, MARDI
Rosli Asaad	20–25 Sep 1985; orchids, MARDI
Rozanor Ghani	20–27 Sep 1985, 7–16 Feb 1986; fungi, MARDI
Salmah Idris	23–26 Jul 1985; dicots, MARDI
Sepiah Muid	23–26 Jul & 20–27 Sep 1985; fungi, MARDI

(3) the Universiti Kebangsaan Malaysia (UKM, National University of Malaysia), Bangi —

G. Davison	7–16 Feb 1986; angiosperms, UPM

(4) the University of Malaya, Kuala Lumpur (UM) (herbarium KLU) —

Haji Mohamed	26 Sep–1 Oct 1985; bryophytes, pteridophytes, KLU
B.H. Kiew	2–6 Sep 1985, 20–27 Mar, 16–22 Apr & 20–28 May 1986; algae, bryophytes, pteridophytes, angiosperms, UPM, KLU
P. Leong	14–18 Jun 1985, 23–31 May 1986; algae, KLU
R.P. Lim	12–13 Feb 1986; algae, KLU
S.M. Phang	2–7, 14–18 Jun & 25 Sep–1 Oct 1985; algae, KLU
E. Soepadmo & students	25 Sep–1 Oct 1985; gymnosperms, angiosperms, KLU
C.E. Taylor	25 Apr–2 May & 19 May–9 Jun 1986; pteridophytes, angiosperms, KLU, KEP

(5) the Universiti Pertanian Malaysia (UPM, Agricultural University of Malaysia), Serdang (herbarium at Department of Biology UPM; at Forestry Faculty UPMF) —

S. Anthonysamy	26–30 Aug 1985, 4–6 Feb 1986; pteridophytes, angiosperms, UPM
Ibrahim Idham	19–23 Aug 1985; angiosperms, UPMF
Jamaluddin Basharuddin	19–23 Aug 1985; angiosperms, UPMF
R. Kiew	2–7 Jun & 26 Aug–7 Sep 1985, 4–6 Feb, 16–22 Apr & 13–22 May 1986; fungi, pteridophytes, gymnosperms, angiosperms, UPM
S. Madhavan	26–30 Aug & 2–6 Sep 1985; pteridophytes, angiosperms, UPM
Razali Salam & students	26–30 Aug 1985; angiosperms, UPM

(6) the Botanic Gardens, Singapore (herbarium SING) —
E.P. Tay .... 25 Oct–1 Nov 1985; ferns, dicots, SING
(7) the National University of Singapore (NUS) (herbarium SINU) —
Ahmad Samsuri .... 16–20 Jun 1986; pteridophytes, angiosperms, SINU)
R. Corlett .... 28 Apr–2 May 1986; angiosperms, SINU
H. Goh .... 28 Apr–2 May 1986; angiosperms, SINU
I. Louis .... 28 Apr–2 May 1986; fungi, SINU
A.N. Rao & students .... 16–20 Jun 1986; angiosperms, SINU
E. Scott .... 28 Apr–2 May 1986; angiosperms, SINU
H. Tan & students .... 16–20 Jun 1986; bryophytes, pteridophytes, angiosperms, SINU
T.K. Tan .... 28 Apr–2 May 1986; fungi, SINU
Y.C Wee & students .... 16–20 Jun 1986; pteridophytes, angiosperms, SINU
(8) the Royal Botanic Gardens, Kew (herbarium K) —
S. Andrews .... 4–7 Feb 1986; dicots, K
J. Dransfield .... 4–7 Feb 1986; palms, K
P.J. Edwards .... 4–7 Feb 1986; pteridophytes, K

The localities from which specimens for herbaria have been collected during the expedition were:

(a) Kampung Peta and the Sungai Endau downstream from Kuala Jasin (eastern portion of the area), by R. Kiew, Ng, Phang, Saw, Taylor, Wong.
(b) Gunung Janing and the Kuala Marong–Kuala Jasin area (eastern portion), by all collectors except G. Davison and R.P. Lim.
(c) Bukit Sengongong and the "Buaya Sangkut" Falls on the Jasin River (southeastern portion), by Leong, Saw, Wong.
(d) Padang Temambun (southeastern portion), by Davison, B.H. Kiew, R. Kiew, Masrom, Nik Mohmed, Razali Baki, Saw, Wong.
(e) the Kuala Kemapan area and Gunung Beremban massif (central region), by B.H. Kiew, R. Kiew, Saw, Wong.
(f) the Kinchin River valley (northeastern portion), by B.H. Kiew.
(g) the Endau River between Kuala Kinchin and Kuala Jasin, by R.P. Lim.
(h) the Selai River valley (southwestern portion), by B.H. Kiew.

Besides specimens for herbaria, live-plant propagules were collected by a few individuals. These included the following:

pteridophytes — P. Bradley (Royal Botanic Gardens, Kew).
orchids — Abdullah Thani, W.H. Lim, Mohamad Yassin, M. Mooruthy, Rosli Asaad, Salmah Idris (MARDI), L.G. Saw (FRIM), Shaharin Yussof (Malayan Nature Society).
palms — Khelikuzzaman Hussain, Mohamad Nasir and Safie Hussin (MARDI), Mat Asri and C.M. Low (FRIM), Mustapha Mohamad (UM), J.J.H. Tan (Malayan Nature Society).
wild yams — Abdullah Thani, Khelikuzzaman Hussain, Mohamad Nasir and Safie Hussin (MARDI).
bananas — Anthonysamy and R. Kiew (UPM), Abdul Malek and Mohamad Shamsudin (MARDI).
monocots other than as named above — Khelikuzzaman (MARDI), Mustapha Mohamad (UM).

dicots — Mat Asri, L.G. Saw and S.K. Yap (FRIM), Abdul Malek, Khelikuzzaman Hussain, Mohamad Nasir, Mohamad Shamsudin and Safie Hussin (MARDI), Mustapha Mohamad and C.E. Taylor (UM), J.J.H. Tan (Malayan Nature Society), C.J. Goh (NUS).

All of the above were collected in the vicinity of Kuala Jasin, Kuala Marong and Gunung Janing, except those by Shaharin Yussof (which also included collections from the vicinity of G. Tiong, the Buaya Sangkut falls on the Jasin, and Padang Temambun) and J.J.H. Tan (which included collections from the vicinity of Kuala Kemapan, the Buaya Sangkut falls, Padang Temambun and the Lemakoh valley).

References

Burkill, I.H. (1927). Botanical collectors, collections and collecting places in the Malay Peninsula. *Gard. Bull. S.S.* 4(4 & 5): 113-202.

Cracium, G.C.J. (1966). Forest Resources Reconnaissance Survey of Malaya, no. 2. Mersing District, Johore. Forest Research Inst., Forest Department, Malaya.

Flynn, R. (1978). The Sumatran Rhinoceros in the Endau-Rompin National Park of Peninsular Malaysia. *Mal. Nat.* 4(2): 5-12.

Gyekis, K.D. (1966). Forest Resources Reconnaissance Survey of Malaya, no. 7. Segamat District, Johore. Forest Research Inst., Forest Department, Malaya.

Hervey, D.F.A. (1882). The Endau and its tributaries. *J. Str. Br., Roy. As. Soc.,* no. 8: 93-124.

Lake, H.W. (1894). A journey to the source of the Indau. *J. Str. Br., Roy. As. Soc.,* no. 25: 1-9.

Lake, H.W. & H.J. Kelsall. (1895). A journey on the Semberong River. From Kuala Indau to Batu Pahat. *J. Str. Br., Roy. As. Soc.,* no. 26: 1-33.

Lee, P.C. (1966). Forest Resources Reconnaissance Survey of Malaya, no. 3. Rompin Forest District, Pahang. Forest Research Inst., Forest Department, Malaya.

Miklucho-Maclay, N. (1875). Ethnologische excursion in Johor. *S. Natuurkundig Tijdschrift voor N. Indie, Thiel* 35: 251-258.

Miklucho-Maclay, N. (1878). Dialects of the Melanesian tribes in the Malay Peninsula. *J. Str. Br., Roy. As. Soc.,* no. 1: 38-44.

Skinner, A.M. (1878). Geography of the Malay Peninsula. *J. Str. Br., Roy. As. Soc.,* no. 1: 52-62.

Steenis-Kruseman, M.J. van. (1950). Malaysian Plant Collectors and Collections, being a Cyclopaedia of Botanical Exploration in Malaysia and a guide to the concerned literature up to the year 1950. In: C.G.G.J. van Steenis (ed.), *Flora Malesiana, Series* 1, Vol. 1, clii + 639 p.

Thomson, J.T. (1881). A sketch of the career of the late James Richardson Logan, of Penang and Singapore. *J. Str. Br., Roy. As. Soc.,* no. 7: 75-81.

A Further Chromosome Count for *Osmunda* (Osmundales) from Peninsular Malaysia

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The near cosmopolitan fern genus *Osmunda* has been well studied cytologically. Autotetraploid and triploid plants were experimentally produced by Manton (1950). In Peninsular Malaysia, the genus is represented by two species, namely *O. javanica* Bl. and *O. vachellii* Hook., and both are uncommon, restricted to a few localities in the primary forests of Pahang. *O. javanica* is also found in the highlands (Cameron Highlands and Fraser's Hill) whilst *O. vachellii* is a species of both higher and lower elevations (Bidin, 1984a).

The cytology of all the three genera in Osmundales (*Osmunda, Todea* and *Leptopteris*) is distinctive and uniform, all have n = 22 (Lovis, 1977). Bidin (1984b) has reported the chromosome number of *O. vachellii* (n = 22) from the National Park Tembeling, in Pahang. The cytology of *O. javanica* is studied and the chromosome number is reported in this paper for the first time.

Squashes made from the tapetal cells of *O. javanica* collected from Telom Valley, Cameron Highlands and grown in the Universiti Kebangsaan Malaysia Glasshouse (UKMB) also showed clearly 2n = 44 (Fig. 1). This finding confirmed the uniformity of the cytology of the genus in Peninsular Malaysia as well as the world.

All the specimens gathered and kept at UKMB were from several localities in undisturbed forests of Pahang, growing in fairly deep shade in permanently damp and

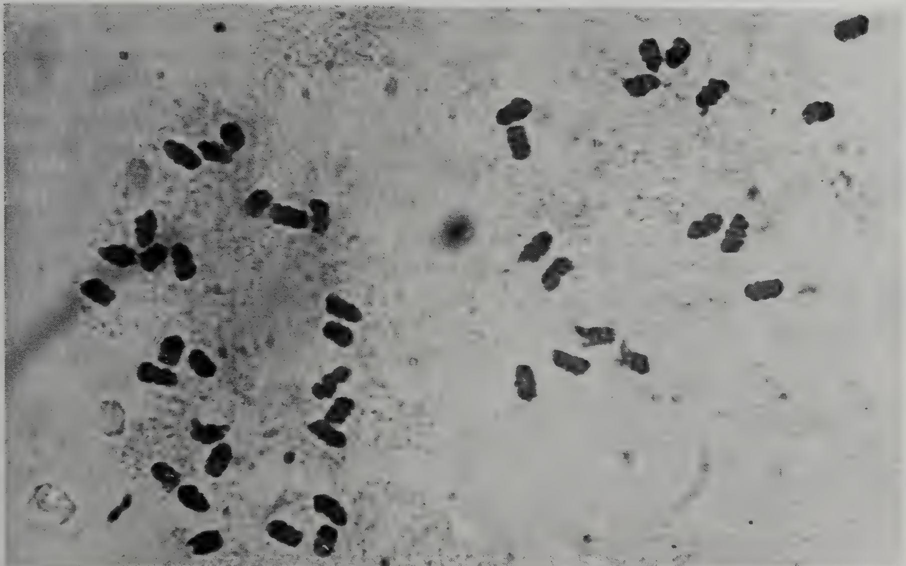

Fig. 1: Mitosis in *Osmunda javanica* Bl. from Cameron Highlands, Pahang. 2n = 44. 1000X

wet habitats. *O. javanica* was collected from Telom Valley, Cameron Highlands and Fraser's Hill (elevation c.4000 ft.); whilst *O. vachellii* was collected from the rocky bank of River Tembeling in Malaysia's National Park (elevation c.50 m).

The plants grew well in the glasshouse and produced sporangia.

Acknowledgements

The author wishes to thank Mr R. Jaman and Miss A. Shaari for assistance in the field and in the laboratory respectively.

References

Bidin, A. (1984a). Ferns of family Osmundaceae in Peninsular Malaysia. *Nature Malaysiana* 9(1): 28–31.

Bidin, A. (1984b). A chromosome count for *Osmunda vachellii* from Peninsular Malaysia. *Fern Gaz.* 12(6): 360–362.

Lovis, J.D. (1977). Evolutionary patterns and processes in ferns. *Adv. Bot. Res.* 4: 229–415.

Manton, I. (1950). *Problems of cytology and evolution in the Pteridophyta*. Cambridge University Press, London.

Book Review

Wayside Trees of Malaya

By E.J.H. Corner, FRS

Third Edition
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Improvements over previous editions are notable. Numerous corrections and updating of scientific names have been made. The index of scientific names has been extended to the species level. Additional and updated information of 'Trees of local interest' has been provided, as has information on growth forms. A guide to tree models is also included.

The text, figures and plates have been divided into two nearly equal volumes, each faced with an attractive colour plate. This is arguably a more practical format than that of previous editions.

Minor mistakes, errors and omissions do crop up: both spellings, *Cratoxylon* and *Cratoxylum* are used (Pg 365); *Kurrimia* is the synonym of *Bhesa* (Pg 246); *Drepananthus* is misspelled as *Drepanthus* (Pg 132); *Anisophyllea* is missing in the new edition, and "Pacific" is printed as "Facific" on the back cover of both volumes. The publishers have noted the error in pages 692 and 694 where SAPINDACEAE should read SAPOTACEAE.

These items seem niggardly in the face of the greater achievement of bringing forth this third edition. Congratulations are in order for Professor Corner, The Malayan Nature Society and Dr Chang Kiaw Lan for her editorial and indexing work.

Reviewed by:
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